# TRANSACTIONS

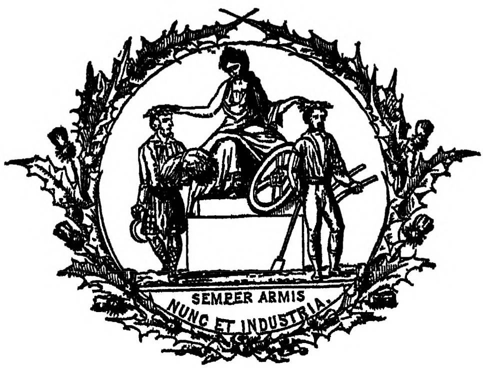
OF

# THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

WITH

AN ABSTRACT OF THE PROCEEDINGS AT BOARD AND GENERAL MEETINGS, AND THE PREMIUMS OFFERED BY THE SOCIETY IN 1895

PUBLISHED ANNUALLY

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## APPENDIX A.



## APPENDIX B.



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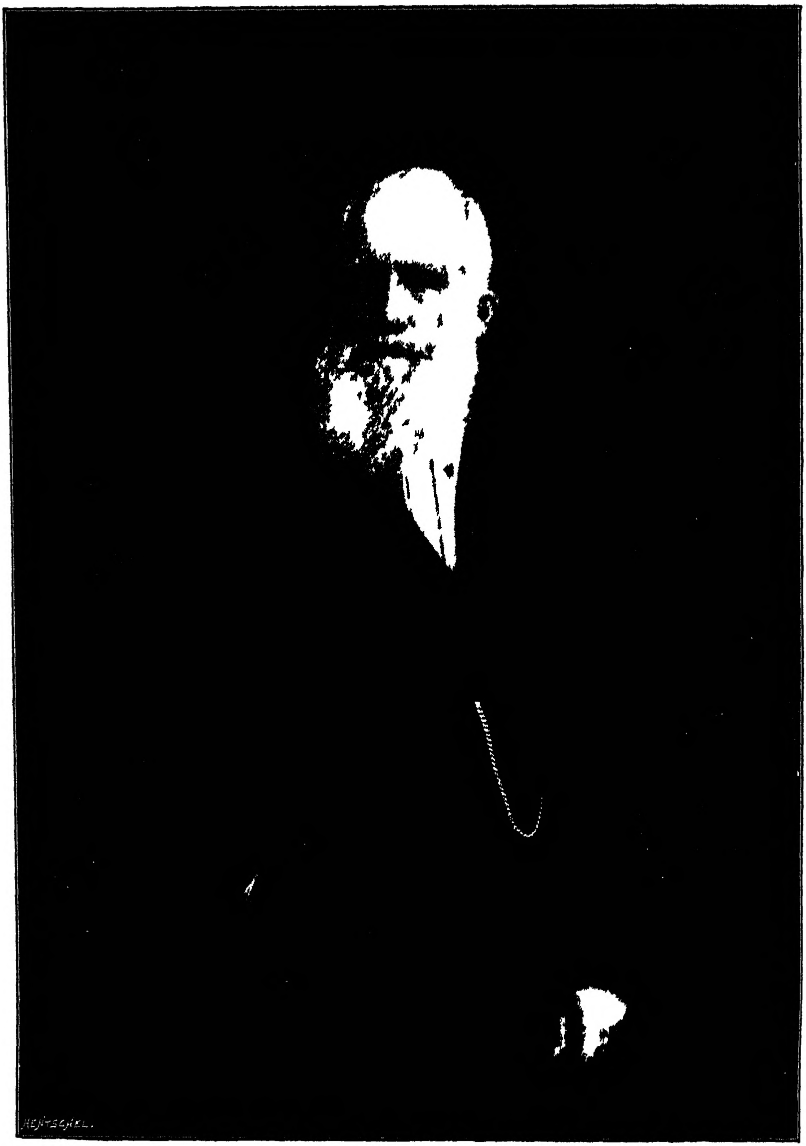
## PLATES.




SIR JOHN BENNET LAWES, BART., D.C.L., LL.D., F.R.S.

# TRANSACTIONS

OF

# THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

## ROTHAMSTED

### PREFATORY NOTE BY THE EDITOR

THE genius of the individual, we are told, is the birthright of mankind. An unostentatious but gifted squire, who has lived an industrious and happy life in the English county of Hertford, has by his genius and public spirit given to the world an inheritance so goodly that its worth can hardly be over-estimated. It is sometimes remarked as curious that while on the continent of Europe and in America there are many Agricultural Experiment Stations, Great Britain, which for centuries has led the van in agricultural progress, can claim to have had for any considerable period of time but one extensive centre of original research. It is equally remarkable that the one extensive and important Experimental Station which Britain does possess should be the oldest in existence, and that it has probably done more solid work for the advancement of agriculture than all its foreign compeers put together.

In the world of science the position of Rothamsted is unique. For more than half a century it has been the largest and most systematically conducted Agricultural Experiment Station in the universe. Abroad, as at home Rothamsted has become a household word. So much accustomed are agriculturists and scientists to speak and think of Rothamsted as a national institution, that it is not often realised that it is absolutely and entirely the undertaking of

a private citizen. The Rothamsted Experimental Station was founded by Sir John Bennet Lawes, has been carried on exclusively at his own expense, and by him it has been bequeathed to the nation, with an endowment ample for all time to come.

The Manor of Rothamsted is situated in the county of Hertford, twenty-five miles north of London, four miles from St Albans, and adjoins the village, and is mainly included in the parish, of Harpenden. It has been in the possession of the present family since 1623. In that year it was purchased from the owner, Bardolf, for John Wittewronge, a minor, whose ancestor, Jaques Wittewronge, had, about 1564, on account of religious persecutions, left Flanders and settled at Stantonbury, in Buckinghamshire. John Wittewronge was first created a knight and afterwards a baronet by Charles II. In the absence of male heirs the baronetcy lapsed, and the Lawes family succeeded to the estate by marriage with Mary Bennet, great-granddaughter of James Wittewronge.

John Bennet Lawes, the first of the name, died in 1822, and was succeeded by his son, the present owner. The son, who was born in 1814, and was thus only eight years of age at the time of his father's death, was educated at Eton and Oxford. He entered into possession of Rothamsted in 1834, and soon after began the great work which has been the chief concern of his long industrious life, and which will make his name familiar through centuries to come.

The Manor-house of Rothamsted is a picturesque structure of considerable antiquity. Dating from about 1470, it has been enlarged and somewhat altered in form at various times. The present owner made extensive additions on one side of the house, but has been careful to preserve the character of the old building, which is well shown in the plate facing page 10.

What manner of man John Bennet Lawes the Second was in his youth, and by what influences he was led into his great work of agricultural research, are quaintly set forth in an autobiographical note written by him in 1888 to his attached friend, the late Mr John Chalmers Morton, editor of the 'Agricultural Gazette.' It runs as follows:—

Dear Mr Morton,—In answer to your inquiries, it is always difficult to predict whether a juvenile taste will develop in after-life into anything useful. To write upon the door of a dark room with a stick of phosphorus, to dissolve a penny in nitric acid, or to convey an electric shock to your old housekeeper, who "refused to touch the jar with her hand, but did not mind touching it with the end of the poker"; these are feats which, with the accompanying destruction of clothes and furniture, cause the elders of the house to look with

unfavourable eyes at a boy with a taste for chemistry. In my day, Eton and Oxford were not of much assistance to those whose tastes were scientific rather than classical, and consequently my early pursuits were of a most desultory character. Matters, however, began to look serious when, at the age of twenty, I gave an order to a London firm to fit up a complete laboratory, and I am afraid it sadly disturbed the peace of mind of my mother to see one of the best bedrooms in the house fitted up with stoves, retorts, and all the apparatus and reagents necessary for chemical research. At that time my attention was very much directed to the composition of drugs. . . .

The active principle of a number of substances was being discovered at this time, and in order to make these substances I sowed on my farm poppies, hemlock, henbane, colchicum, belladonna, &c. Some of these are still growing about the place. Dr A. T. Thomson had suggested a process for making calomel and corrosive sublimate, by burning quicksilver in chlorine gas. I undertook to carry out the process on a large scale, and wasted a good deal of time and money on a process which was, in fact, no improvement on the process then in use. Failures, however, have their value, as I found out afterwards. All this time I had the home farm of about 250 acres in hand. I entered upon it in 1834. Farmers were suffering from the abundance of the crops, and wheat, although rigidly protected, was very low in price. For three or four years I do not remember that any connection between chemistry and agriculture passed through my mind; but the remark of a gentleman who farmed near me, who pointed out that on one farm bones were invaluable for the turnip crop, and on another farm they were useless, attracted my attention a good deal, especially as I had spent a good deal of money on bones without success. Somewhere about this time a drug-broker in the city of London asked me whether I could make use of precipitated gypsum and spent animal charcoal, both of which substances held at the time no market value. Some tons of these were sent down, and, as sulphuric acid was largely used by me in making chlorine gas, the combination of the two followed.

The successful application of the superphosphate on my own fields caused me to take out a patent and to send it out for trial elsewhere. I put up an edge-runner to grind the charcoal finer, but to manufacture the substance on a large scale profitably with a carriage of twenty-five miles by waggon was out of the question. It was, however, a serious step to set up a manufactory in London, and it did not take place for some years afterwards. All this time I was carrying on a very large number of experiments with chemical manures, but they were performed upon areas of land too small to give trustworthy acreage results. I think the *Gardeners' Chronicle*, which was first published in 1840, contains the result of my earliest experiments with various chemical salts. . . . J. B. LAWES.

ROTHAMSTED, ST ALBANS.

Great undertakings have small beginnings. The Rothamsted experiments were begun with plants in pots. This occurred soon after 1834, in which year, as has been seen, Sir (then Mr) John Bennet Lawes entered into possession of his hereditary property at Rothamsted. The trials were afterwards taken to the field, the researches of De Saussure on vegetation being the chief subjects of study at this time. Of all the initial experiments made, those in which the

neutral phosphate of lime, in bones, bone-ash, and apatite, was rendered soluble by means of sulphuric acid, and the mixture applied for root-crops, gave the most striking results. The results obtained on a small scale in 1837, 1838, and 1839 were such as to lead to more extensive trials in the field in 1840, 1841, and subsequent years.

The importance to agriculture of these early experiments cannot easily be estimated. In them was first observed the excellent results produced by manuring turnips with super-

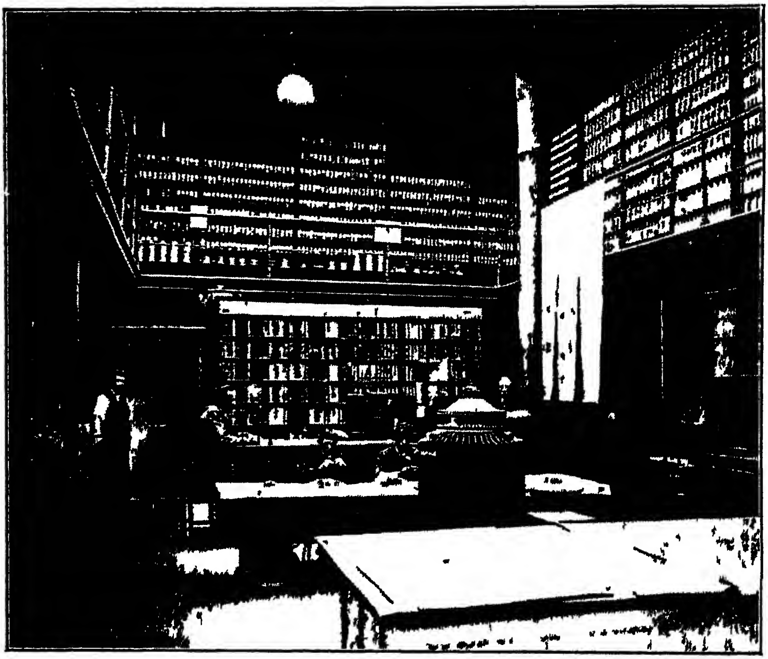


FIG. 1—THE ROTHAMSTED LABORATORY—FRONT LABORATORY AND SAMPLE-GALLERIES

phosphates—mineral phosphates previously dissolved in sulphuric acid. Their success in this particular led Sir John Bennet Lawes to take out a patent in 1842 for the manufacture of superphosphate, and thus was formed the beginning of the artificial manure industry which has revolutionised British agriculture.

But although some valuable work had been done in these earlier years, the foundation of the Rothamsted Experimental Station is usually assigned to the year 1843. In that year the field experiments were begun in a systematic manner;

and a barn which had previously been partly applied to laboratory purposes, became almost exclusively devoted to agricultural investigations.

It is interesting to note that the foundation of the Experimental Station at Rothamsted is earlier than that of any other, with the single exception of Boussingault's Station at Bechelbronn in Alsace. The earliest Station in Germany was established at Mockern in 1852; that in America at Middletown, Connecticut, in 1875.

In June of 1843 Sir John Bennet Lawes obtained the services of Dr (now Sir) J. Henry Gilbert to aid him in his

FIG. 2.—THE ROTHAMSTED SAMPLE-HOUSE—ROOM FOR SAMPLES OF SOILS, GRAINS, ETC., ETC.

researches, and continuously from that date the two have been associated in the conduct of the experiments. Prior to the appointment of Dr Gilbert as chemist, Sir John Bennet Lawes had for some time the assistance of a young chemist named Dobson.

The staff of assistants employed at Rothamsted has increased from time to time. At first only one laboratory man was employed. Very soon a chemical assistant was necessary, and after him came a computer and record-keeper.

Since about 1853 the staff has consisted of the following: (1) One or two, and sometimes three, chemists. (2) Two or

three general assistants. One of these is usually employed in routine chemical work, but sometimes in more general work. The chief occupation of the general assistants is to superintend the field experiments—that is, the making of the manures, the measurement of the plots, the application of the manures, and the harvesting of the crops; also, the taking of samples, the preparation of them for preservation or analysis, and the determinations of dry matter, ash, &c. These assistants also keep the meteorological records, and superintend any experiments made with animals. (3) A botanical assistant has occasionally been employed, with from three to six boys under him; and with him has been associated one of the permanent general assistants, who at other times undertakes the botanical work. (4) Two or three, latterly four, computers and record-keepers have been occupied in calculating and tabulating field, feeding, and laboratory results, copying, &c. (5) A laboratory man and other helps are also employed. Thus, in addition to a considerable number of agricultural labourers, there have usually in recent years been from ten to twelve assistants employed at the Rothamsted Experimental Station.

Then, besides the permanent laboratory staff resident at Rothamsted, chemical assistance has frequently been engaged in London or elsewhere. In this way Mr R. Richter, now of Charlottenburg (Berlin), but who was for some years in the laboratory at Rothamsted, has executed much analytical work sent from Rothamsted. He has, indeed, at Rothamsted and Charlottenburg, made nearly 800 complete analyses of the ashes of various products, animal and vegetable, of known history.

It is not easy to form anything like an accurate idea of the vast amount of sampling and analytical work that has been involved in the Rothamsted experiments. Figures 1 and 2 on pages 4 and 5 afford but a slight indication of the vastness of this branch of the work. There is now in one or other of the buildings a collection of over 40,000 bottles of samples of experimentally grown vegetable produce, of animal products, of ashes or of soils, and besides these there are some thousands of samples not in bottles. A capacious "Sample-House" was built in 1888, and already it is becoming inconveniently full.

The barn-laboratory which did duty in the earlier years of the experiments was ere long found inadequate for the increasing amount of laboratory work. Very appropriately, therefore, a testimonial which a number of leading agriculturists desired to present to Sir John Bennet Lawes took the form of a laboratory. The construction of the Presentation

Laboratory was begun in 1854, and it was opened at a public gathering, at which the Earl of Chichester presided, on the 19th of July 1855.

As already indicated, the Rothamsted Experimental Station has from the commencement been entirely disconnected from any external organisation, and has been maintained solely at the cost of Sir John Bennet Lawes. For the continuance of the investigations after his death he has set apart a sum of £100,000, besides the Laboratory and certain areas of land. In February 1889 trustees were appointed, and a trust-deed was executed. Soon after, in accordance with the provisions of the deed, a Committee of Management was appointed, and entered upon its duties.

The following are the Trustees, viz.:—

Sir John Lubbock, Bart., F.R.S.
Lord Walsingham, F.R.S.
Sir John Evans, K.C.B., Treasurer of the Royal Society.

The Committee of Management consists of the following nine members, viz.:—

| | Nominated by |
|---|---|
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| Dr Hugo Muller, F.R.S. (*Treasurer*) | The Royal Society. |
| Professor M. Foster, Sec. R.S. | The Royal Society. |
| W. T. Thiselton Dyer, C.M.G., F.R.S. | The Royal Society. |
| Professor H. E. Armstrong, F.R.S., late Pres. Chem. Soc. | The Chemical Society. |
| William Carruthers, F.R.S. | The Linnæan Society. |
| Sir John H. Thorold, Bart. | The Royal Agricultural Society of England. |
| Charles Whitehead, F.L.S. | The Royal Agricultural Society of England. |
| Sir John Bennet Lawes, Bart. | |

In recognition of his eminent services to agriculture, Mr John Bennet Lawes was created a baronet in 1882. He received the degree of LL.D. from Edinburgh in 1877, of D.C.L. from Oxford in 1892, and of Sc.D. from Cambridge in 1894. He was elected a Fellow of the Royal Society in 1854.

The Jubilee of the Rothamsted Experimental Station in 1893 was made the occasion of a ceremonial which was of an unique and interesting character. At a meeting held at the offices of the Royal Agricultural Society of England, 12 Hanover Square, London, on 1st March 1893, and presided over by H.R.H. the Prince of Wales, it was resolved that, to mark the completion of half a century of continuous research in the Rothamsted Station, some public recognition should be made of the invaluable services rendered to agriculture by Sir John Bennet Lawes and Dr Gilbert. It was decided that subscriptions to the fund should be limited to two guineas, and that the testimonial should take the form of (1)

a granite memorial with a suitable inscription, to be erected in front of the Laboratory at Harpenden; (2) illuminated addresses of congratulation to Sir John Bennet Lawes and Dr Gilbert; and (3) such other presentations as funds permitted. An influential executive committee was appointed, and very soon a sum of over £700 was raised by 447 subscribers. The committee were thus enabled, in addition to providing the granite memorial and addresses, to commission Mr Hubert Herkomer, R.A., to paint Sir John Bennet Lawes' portrait for presentation to him. The illuminated addresses were signed by H.R.H. the Prince of Wales on behalf of the subscribers.

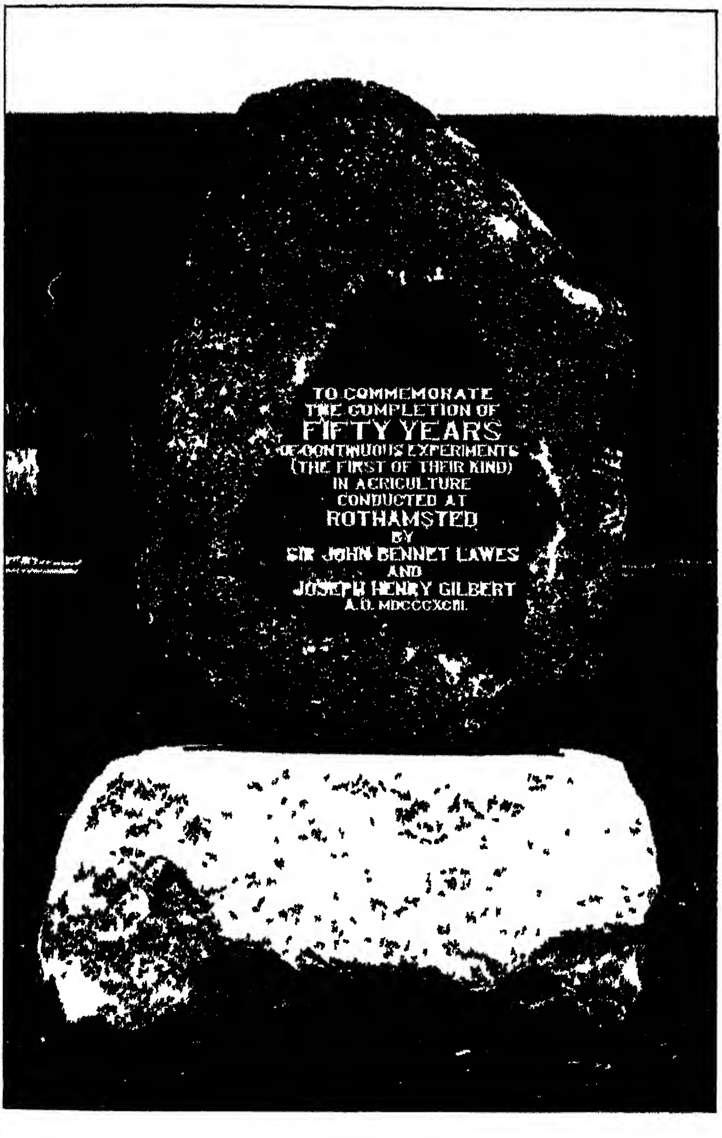
The various presentations were made, and the commemorative granite boulder was formally dedicated, at a meeting of the subscribers held at Harpenden, on Saturday, July 29, 1893. The Right Hon. Herbert Gardner, M.P., President of the Board of Agriculture, presided, and there was a large attendance of leading agriculturists, scientists, and others.

The granite memorial consists of a huge monolithic boulder of irregular shape obtained from the Shap Granite Company's quarries in Westmoreland. Its total weight is eight tons, and it rests upon a base of granite taken from the same source. The boulder, which is represented opposite, stands on a grassy slope in front of the Presentation Laboratory at Harpenden, and a polished panel facing the roadway bears the following inscription, viz.:—

TO COMMEMORATE
THE COMPLETION OF
FIFTY YEARS
OF CONTINUOUS EXPERIMENTS
(THE FIRST OF THEIR KIND)
IN AGRICULTURE
CONDUCTED AT
ROTHAMSTED
BY
SIR JOHN BENNET LAWES
AND
JOSEPH HENRY GILBERT
A.D. MDCCCXCIII.

The presentation portrait of Sir John Bennet Lawes is a life-sized three-quarter length, representing Sir John standing in a characteristic attitude, facing the spectator. A brass plate at the foot contains the following inscription:—

PRESENTED BY SUBSCRIPTION TO SIR JOHN B. LAWES, BART., D.C.L., LL.D., F.R.S., TO COMMEMORATE THE JUBILEE OF THE ROTHAMSTED EXPERIMENTS, JULY 29TH, 1893.




ROTHAMSTED JUBILEE BOULDER.

At the same time a massive silver salver, bearing the following inscription, was presented to Dr Gilbert, viz. :—

PRESENTED BY THE SUBSCRIBERS TO THE ROTHAMSTED JUBILEE FUND TO DR JOSEPH HENRY GILBERT, F.R.S., IN COMMEMORATION OF THE COMPLETION OF FIFTY YEARS OF UNREMITTING LABOUR IN THE CAUSE OF AGRICULTURAL SCIENCE, JULY 29TH, 1893.

Besides the addresses from the subscribers to the Jubilee Fund, numerous other addresses from Scientific and Agricultural Institutions at home and abroad were either on the same occasion or at other times during the year 1893 presented to Sir John Bennet Lawes and Dr Gilbert. Amongst these was an address to Sir John Bennet Lawes from the Highland and Agricultural Society. This address was adopted at a General Meeting on 14th June 1893, and runs as follows, viz. :—

SIR,—We, the members of the Highland and Agricultural Society of Scotland, in General Meeting assembled, embrace this opportunity of offering to you our heartiest congratulations upon the attainment of the jubilee of the splendid lifework in which you have been engaged at Rothamsted. Without parallel, either as to extent, character, or scientific and practical usefulness, the Rothamsted experiments have done more to advance agricultural science, and have been and will be of greater service to agriculture than can ever be fully realised. In these unique experiments, and in the munificent provisions you have made for their continuation, the nation has received an inheritance of inestimable value. In approaching you, therefore, with our congratulations upon the completion of half a century of your great work of scientific agricultural research, we would desire also to record our appreciation of the public spirit and benevolence which you have displayed in establishing and carrying on the Rothamsted experiments; to convey to you our high sense of personal regard for yourself; and to express our earnest hope that you may be long spared to enjoy in good health the quiet evening of a life that has been unusually active and abundantly fruitful in good work.

The portrait of Sir John Bennet Lawes, facing page 1, is from a recent photograph by Elliott & Fry, London. Sir John, now in his eighty-first year, is hale and hearty, and as actively interested as ever in his great lifework.

On August 11, 1893, that is, about a fortnight after the Jubilee celebration at Rothamsted, Dr Gilbert received the honour of knighthood. Sir Joseph Henry Gilbert was born at Hull in 1817, so that he is three years the junior of Sir John Lawes. Sir J. H. Gilbert's father was the Rev. Joseph Gilbert, and his mother, Ann Taylor of Ongar, was well known as an authoress. His college studies were begun at Glasgow, and finished at the University College, London. From the outset he devoted special attention to chemistry,

and spent a short time in the laboratory of Professor Liebig at Giessen, Germany, where he took the degree of Doctor of Philosophy. As has already been indicated, Sir J. H. Gilbert has, since June 1, 1843, been continuously associated with Sir John Bennet Lawes in the conduct of the Rothamsted Experimental Station. All through this period he has been Director of the Rothamsted Laboratory.

Sir J. H. Gilbert was elected a member of the Chemical Society in 1841, the year of its formation, and was President of the Society in 1882-83. He was elected a Fellow of the Royal Society in 1860, and in 1867 the Council of the Society awarded to him, in conjunction with Sir John Bennet Lawes, one of the Royal Medals. He is also a Fellow of the Linnæan Society, and of the Royal Meteorological Society. He received the honorary degree of M.A. at Oxford in 1884, that of LL.D. at Glasgow in 1883 and at Edinburgh in 1890, as also that of Sc.D. at Cambridge in 1894. He was Sibthorpian Professor of Rural Economy in the University of Oxford for six years, from 1884 to 1890.

In May 1893, the President and Council of the Society of Arts awarded the Albert Gold Medal both to Sir John Lawes and to Sir Henry Gilbert "for their joint services to scientific agriculture, and notably for the researches which, throughout a period of fifty years, have been carried on by them at the experimental farm, Rothamsted"; and the medals were presented to them at Marlborough House by H.R.H. the Prince of Wales, President of the Society, in February 1894, in the presence of many members of the Council of the Society.

The Lawes Agricultural Trust provides that some one shall periodically visit the United States of America, and give a series of lectures upon the results of the Rothamsted investigations. At the request of the Committee of Management, Sir J. H. Gilbert undertook this duty in 1893, and thus for the third time he visited the New World beyond the Atlantic, his former visits having taken place in 1882 and 1884. Like Sir John Bennet Lawes, he is an honorary or corresponding member of numerous home and foreign agricultural and scientific societies.

The portrait of Sir J. Henry Gilbert, facing page 19, is from a recent photograph by Wilkinson, Harpenden.

In the pages which follow, Sir John Bennet Lawes and Sir J. Henry Gilbert give an interesting review of an important section of the great work of research which for more than half a century has been the chief concern of their busy lives.

JAMES MACDONALD.

ROTHAMSTED MANOR-HOUSE

# THE ROTHAMSTED EXPERIMENTS.

BEING AN ACCOUNT OF

SOME OF THE RESULTS OF THE AGRICULTURAL INVESTIGATIONS CONDUCTED AT ROTHAMSTED, IN THE FIELD, THE FEEDING-SHED, AND THE LABORATORY, OVER A PERIOD OF FIFTY YEARS.

By Sir JOHN BENNET LAWES, Bart., D.C.L., Sc.D., F.R.S., and
Sir J. HENRY GILBERT, LL.D., Sc.D., F.R.S.

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## CONTENTS.

## *INTRODUCTION.*

THE more systematic experiments at Rothamsted were commenced in 1843, so that 1893 was the fiftieth year of their continuance. In accordance with a request made by Mr James Macdonald on behalf of the Highland and Agricultural Society of Scotland soon after the celebration of the jubilee of the investigations in 1893, it is proposed to give in the following pages such a general view of the half-century's work and results as is practicable within the limits assigned to us; but it will be readily understood that it is no easy task to compress within even the liberal space allotted to us anything like an adequate account of the labours of a gradually increasing staff of workers over a period of fifty years. This will be fully recognised when it is borne in mind that the reports and other publications on the results which have already appeared number about 120, and that they occupy about 4000 octavo and more than 800 quarto pages; whilst there still remain considerable arrears of as yet unpublished results. It is, in fact, from this mass of material, published and unpublished, that selection has to be made in endeavouring to give such a view of the objects, plan, and results, of the investigations, as may be of value as illustrating the advance in knowledge acquired.

Obviously, the scheme proposed precludes the idea of going into full detail on any one subject, and supposes rather a comprehensive but at the same time only outline view of the whole. The first question to consider is—Whether the illustrations relied upon should have reference primarily to results obtained in the field and in the feeding-shed, or chiefly to those of the laboratory investigations? As a prominent characteristic of the Rothamsted work has been the devotion of great attention to both field and feeding experiments, and as by far the greater part of the laboratory investigations, whether chemical or botanical, have had for their object the solution of problems suggested by the

field and feeding results, it has been thought that the most appropriate, and at the same time the most useful course, will be to give as complete a view as practicable of the plan and results of some of the field and feeding experiments themselves, and to enforce the lessons which they teach by such reference to laboratory results as the questions raised require for their elucidation, and as space will permit. In other words, the analytical and other laboratory work must be treated as essential means to an important end, and cannot, within the limits of this review, be made the subject of critical consideration as such; and here it should be observed that nothing is done at Rothamsted, in the way of manure, or feeding-stuff analysis, or seed control, for any purposes external to those of the investigation.

Although, as has been said, a large amount of field, feeding, and analytical results still remains unpublished, yet fortunately a much larger amount has already been put on record. Hence it may be that some of our readers will be disposed to say that they knew much of what is here given before. On the other hand, probably a larger number are not so well acquainted with what has been written; and most may probably feel that the outline here provided will serve the useful purpose of assisting them the more effectively to study the fuller published records. Indeed, the object in view throughout has been to afford guidance for further study, rather than to attempt the impossible task of giving anything like an adequate account of the very numerous and varied results that have been obtained.

As a useful preliminary to further explanation of the plan of illustration proposed, it will be convenient to call attention to the general arrangement of the field experiments, and also to their extent and duration, as given in Table I.

In further explanation, it may be stated that the general plan of the field experiments has been, to grow some of the most important crops of rotation, each separately, year after year, for many years in succession on the same land, without manure, with farmyard manure, and with a great variety of chemical manures; the same description of manure being, as a rule, applied year after year on the same plot. Besides the experiments on the growth of individual crops year after year on the same land under different conditions as to manuring, what may be called complementary experiments have been made on the growth of crops in an actual course of rotation, without and with different manures; also others on the mixed herbage of permanent grass-land, both without and with various manures. It is to be understood that the arrangement of the manures is made entirely regardless of the comparative cost as between plot and plot, the question at issue being one of constituents against constituents, and not of shillings against shillings.

TABLE I.—List of the Rothamsted Field Experiments.

| | Commencing | Number of years | Area, acres. | Number of Plots. |
|---|---|---|---|---|
| Wheat (various manures) . . | 1843-4 | 50 | 11 | 34 (or 37) |
| Wheat, alternated with fallow . | 1851 | 43 | 1 | 2 |
| Wheat (varieties) . . . | 1867-8 | 15 | 4-8 | about 20 |
| Barley (various manures) . . | 1852 | 42 | $4\frac{1}{4}$ | 29 |
| Oats (various manures) . . . | 1869 | 10[1] | $0\frac{3}{4}$ | 6 |
| Beans (various manures) . . | 1847 | 32[2] | $1\frac{1}{4}$ | 10 |
| Beans (various manures) . . | 1852 | 27[3] | 1 | 5 |
| Beans (alternated with wheat) . | 1851 | 28[4] | 1 | 10 |
| Clover (various manures) . . | 1848-9 | 29[5] | 3 | 18 |
| Various leguminous plants . . | 1878 | 16 | 3 | 18 |
| Turnips (various manures) . . | 1843 | 28[6] | 8 | 40 |
| Sugar-beet (various manures) . | 1870 | 5 | 8 | 41 |
| Mangel-wurzel (various manures) . | 1876 | 18 | 8 | 41 |
| Total . . | | 51 | | |
| Potatoes (various manures) . . | 1876 | 18 | 2 | 10 |
| Rotation (various manures) . . | 1848 | 46 | 3 | 12 |
| Permanent grass (various manures) | 1856 | 38 | 7 | 22 |

[1] Including one year fallow.
[2] Including one year wheat, and five years fallow.
[3] Including four years fallow. [4] Including two years fallow.
[5] Clover, twelve times sown (first in 1848); only eight crops, four very small; one year wheat, five years barley, twelve years fallow.
[6] Including barley without manure three years, 1853-55.

It is obvious that the results of field experiments with the individual crops, conducted as above described, must of themselves throw much light on the characteristic requirements of the particular crop under investigation, whilst those of the experiments on the growth of crops in an actual course of rotation will serve to confirm and control those obtained with the individual crops, and will in their turn receive elucidation from the results with the individual crops. Then, again, the results of the experiments on the application of different manures to the mixed herbage of grass-land—which includes, among others, members of the botanical families that contribute some of the most important of our rotation crops—may, independently of their value in reference to the special objects for which they were undertaken, be expected to afford interesting collateral evidence in regard to the requirements of individual plants when thus grown in association, instead of separately year after year, or in rotation, as in the other series of experiments. Obviously, too, the chemical, and in some cases the botanical,

statistics of the crops so variously grown, and the chemical statistics of the soils of the plots upon which they have been grown, must afford very important data for further study and elucidation.

An examination of Table I. will show that the individual crops which have been grown separately year after year on the same land include—wheat, barley, and oats, as members of the order Gramineæ; beans, clover, and other plants, of the order Leguminosæ; turnips of the Cruciferæ; sugar-beet and mangel-wurzel of the Chenopodiaceæ; and potatoes of the Solaneæ. Then the experiments on rotation include those with members of three of the above orders—turnips of the Cruciferæ, barley and wheat of the Gramineæ, and clover and beans of the Leguminosæ. Lastly, there are the experiments on the mixed herbage of permanent grass-land, which includes, besides gramineous and leguminous plants, numerous species of other natural orders.

The first experiments undertaken were those with root-crops, which were commenced in June 1843, so that last year (1894) was the fifty-second of their continuance. The second were those on wheat, commenced in the autumn of 1843, so that the crop of the last harvest was the fifty-first grown in succession on the same land. The experiments with beans were commenced in 1847; but, for reasons which will be fully explained, they have not been continued up to the present time. Those with clover were commenced in 1848, and have been succeeded on the same land by others with various leguminous plants, which are still continued. Then of the other more important series, those on barley were commenced in 1852, and are still in progress, the crop of 1894 being, therefore, the forty-third in succession. Experiments with oats were commenced in 1869, and continued for ten years. Others, on the growth of wheat alternated with fallow, but without manure, were commenced in 1851, and are still going on, 1894 being the forty-fourth year; and those on potatoes were commenced in 1876, the crop of 1894 making, therefore, the nineteenth in succession. The experiments on an actual course of rotation were commenced in 1848, and are still continued, so that the crop of wheat now growing will complete the twelfth course of four years, and the forty-eighth year of the experiments. Lastly, those on the mixed herbage of permanent grass-land were commenced in 1856, so that 1894 completed the thirty-ninth year of their continuance.

It should be observed that the earlier field experiments were commenced without any idea of long continuance, and it was only as the results obtained indicated the importance of such continuance that the plan eventually adopted was gradually developed. It is, however, to long continuance that we owe

some of the most interesting and the most valuable of our results, as will be fully illustrated as we proceed.

Table I. further shows the area, and the number of plots, under experiment in each case; and it may be stated that the total area under exact and continuous experiment has been for some years, and is at the present time, about 40 acres.

The next point to consider is—What is the most appropriate selection to make among the field and other results; and what is the most appropriate order in which to consider them, in attempting to illustrate the objects, plan, and results, of the Rothamsted investigations? It will be readily understood that our selection of crops for investigation was largely influenced by the actual practice of our own part of the country. The separately grown individual crops were, in fact, the chief of those entering into our rotations; whilst the rotation selected for study was the well-known "four course"—namely, roots, barley, leguminous crop (or fallow), and wheat. Obviously, therefore, the most natural order of illustration would be that indicated by the ideas and conditions in accordance with which the experiments have been arranged and conducted; and the order so indicated will, we think, be found to be, upon the whole, not only the most convenient but the most instructive.

We have, it is true, in different parts of the country a great variety of soil and of climate, and accordingly great variety in crops, and in the order of their rotation. Still, it will be seen that the selection of individual crops experimented upon includes most, and certainly the most typical, of those grown in the varied rotations of different parts of the country; and it will be admitted that, in some important respects, the characteristic requirements of the individual crops are very similar whether grown in one locality or in another. Indeed, it cannot fail to be recognised that, *mutatis mutandis*, the results which have been obtained under given conditions at Rothamsted are not without their significance and bearing, under the different conditions of other localities.

In accordance with what has been said, it is proposed to consider the results obtained, with the selection of the crops experimentally grown, and in the laboratory investigations connected with them, as given in the following list. Lastly, it will be seen that the very important complementary subject of the feeding of animals will also be considered.

1. Root-crops—Common turnips, Swedish turnips, sugar-beet, and mangel-wurzel; each grown continuously.
2. Barley—grown continuously.
3. Leguminous crops—Clover, beans, and various other Leguminosæ; mostly grown continuously. Also the question of the fixation of free nitrogen.

4. Wheat—grown continuously.
5. Rotation of crops — Root-crops (Swedish turnips), barley, leguminous crops (or fallow), and wheat.
6. Results of experiments on the feeding of animals—for the production of meat, milk, and manure, and for the exercise of force.

It will be observed that Nos. 1, 2, 3, and 4, refer to the individual crops grown continuously; and No. 5 to the same crops grown in rotation. Reference to the list given in Table I. will show, however, that among the field experiments there enumerated there will still remain untouched the following:—

The experiments with oats grown continuously;

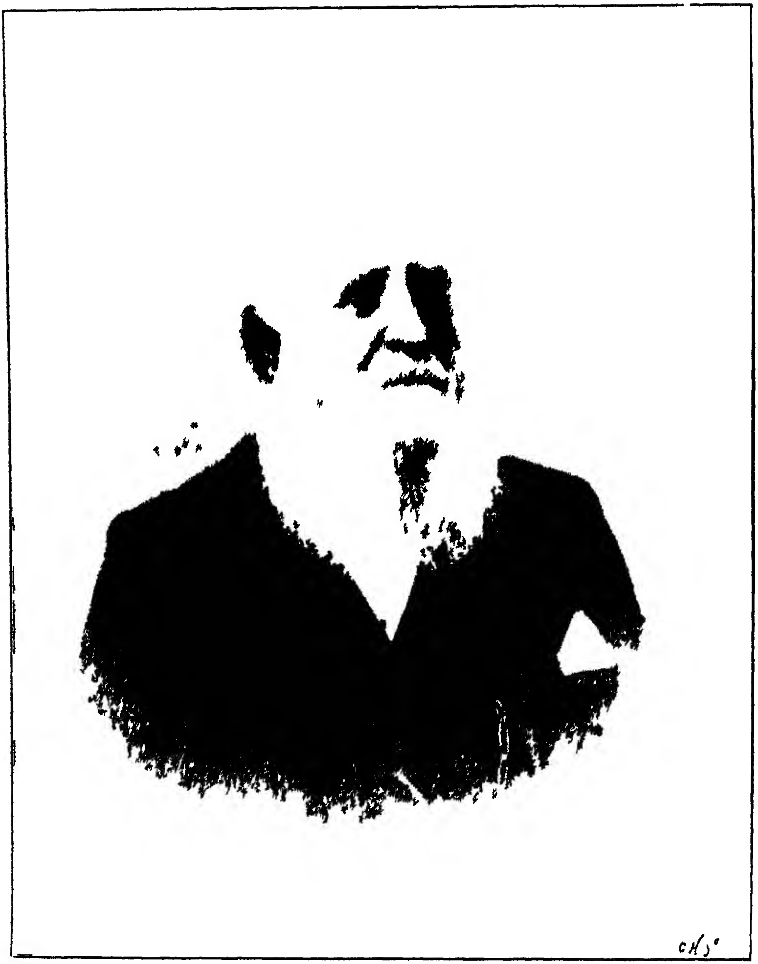
Those with potatoes grown continuously;

Those on the alternation of wheat and fallow;

The very extensive series on the mixed herbage of permanent grass-land—including results as to the amounts of produce obtained, and those relating to its composition, both botanical and chemical.

There also remains the extensive series of investigations on rainfall and drainage—their quantity and composition.

It seemed, indeed, desirable that as complete a view as practicable within the space to be occupied should be given of the investigations selected for illustration; leaving the subjects which it was not possible so to include to be studied, by those who desire so to do, in the various papers relating to them which have been published elsewhere, and to which full reference is given in the lists of papers which will be found in the annually issued 'Memoranda of the Origin, Plan, and Results of the Field, and other Experiments, conducted on the Farm and in the Laboratory,' at Rothamsted. In the same document will also be found, besides much general information in regard to the experiments, descriptive and numerical details relating not only to the experiments which will be treated of in the following pages, but also to those the consideration of which cannot be included in the present Report.



SIR JOSEPH HENRY GILBERT, M A., PH D, LL D., F R S

## *SECTION I.—EXPERIMENTS WITH ROOT-CROPS GROWN CONTINUOUSLY; BARNFIELD, ROTHAMSTED.*

### *Introduction.*

*Conditions of growth of root-crops.*

The *Root-crops*, the conditions of growth and the composition of which we have first to consider, include members of more than one natural Order of plants; and they are grown for, so to speak, certain intermediate parts and products, which are, by cultivation, very abnormally developed; whilst the crops are not allowed to ripen, but are taken when in a succulent and immature condition. We shall thus have interesting points of comparison, or contrast, brought out, as to the conditions of growth of these crops, and of those to which we owe ripened products, such as the cereal grains.

The crops to which we shall specially direct attention are—some varieties of turnips belonging to the Order Cruciferæ, and two varieties of beet, namely, the sugar-beet, and the feeding mangel, of the Order Chenopodiaceæ.

*Importance of turnip crop.*

The introduction of turnips into our rotations may be said to have been one of the most important improvements of modern times. The growth of the crop constitutes indeed an essential element, not only in the ordinary four-course rotation, but in all our varied rotations.

*Root-crops and nitrogen.*

From certain characters of the turnip plant, and of other root-crops, especially their abundant leaf-surface, and from certain conditions of their growth, it has frequently been assumed that they are largely dependent on the atmosphere for their nitrogen; and that they are in fact thus collectors of nitrogen for the crops grown in alternation with them. But we shall see that experimental evidence does not support this conclusion; and that we must look in other directions for an explanation of the undoubted benefits of the growth of root-crops in rotation.

*Abnormal root development.*

The object to be attained in the cultivation of root-crops is to encourage, by artificial means, a quite abnormal development of a particular part of the plant. If, for example, the turnip-plant were grown for its natural seed-product—*oil*—a heavier soil would be more suitable than when the object is to develop the swollen root. In our climate a biennial habit would be induced, and it would be so grown as to be exposed to the summer temperature at a later stage of the life-history of the plant—that is, at the seed-forming and ripening period. Under these circumstances there would be much less of fibrous root distributed through the surface-soil, the main root would be much more fusiform, tapping rather than

spreading laterally, the leaves and stem would be larger, both actually and proportionally to the root, and the enlarged root itself would serve as a store of material for the second or final growth.

To obtain the cultivated root, however, as grown as a rotation and food crop, the conditions required are very different. The seed is sown at a different period, and the character of the manuring, and of the season of growth chosen, are in their conjoint influence such as to favour a very abnormal accumulation of the store-material in the root, and to secure that this development shall attain a maximum within the limits of the season. It will be seen, however, that the cultivated turnip very soon reverts to its more natural characteristics if the mode of treatment be not such as to favour the artificial development.

*Turnips reverting.*

The first results to be adduced relate to experiments with a variety of the common turnip, or *Brassica rapa.*

## 1. *Experiments with Norfolk White Turnips.*

*Common practice of root culture.*

Root-crops—whether common turnips, Swedish turnips, or mangel-wurzel—are in ordinary practice grown by the aid of large dressings of farmyard manure, with or without artificial manures in addition. The farmyard manure is in some cases applied for the preceding grain crop, but more generally directly for the root-crop itself. The following table shows the results obtained with Norfolk white turnips, both without manure, and by 12 tons of farmyard manure applied annually for three years in succession.

TABLE 2.—PRODUCE OF NORFOLK WHITE TURNIPS.

| Seasons. | Roots. | | | | Leaves. | | | |
|---|---|---|---|---|---|---|---|---|
| | Without manure. | | With farmyard manure | | Without manure | | With farmyard manure. | |
| | tons. | cwt | tons. | cwt. | tons. | cwt. | tons. | cwt |
| 1843 . . . | 4 | 3¾ | 9 | 9½ | Not weighed | | Not weighed | |
| 1844 . . . | 2 | 4¼ | 10 | 15¼ | | | | |
| 1845 . . . | 0 | 13¾ | 17 | 0¾ | 0 | 14¼ | 7 | 7¾ |
| Mean . . | 2 | 7¼ | 12 | 8½ | | | | |

*Without manure.*

Thus, the produce of this assumed restorative crop, when grown without manure, went down in the third year to practically nothing—only 13¾ cwt. per acre; whilst in the third year with farmyard manure there was more than 17 tons. But the amount varied very much according to

*With dung.*

season, it being nearly twice as great in the third year as in the first.

Now, the farmyard manure employed would contain much more of nitrogen, and also of most of the mineral constituents, than the crops grown.

*Advantages of the root-crop in a rotation.*

The fact is that, independently of the great advantage accruing from the opportunity for cleaning the land, the value of the root-crop in rotation is mainly to be attributed to the large amount of farmyard manure generally applied for its growth; to the large proportion of the constituents of the manure which remain, and become slowly available to succeeding crops; to the large amount of the nitrogen and other constituents remaining in the leaf, which serve directly as manure again. Then they are gross feeders, so to speak, converting a large amount of manure into vegetable produce; whilst, when the edible portion—the root—is consumed by store or fattening stock, a very small proportion of the nitrogen, and of other constituents valuable as manure, is retained by the animal; the remainder, perhaps more than 90 per cent, of the nitrogen, being voided, becoming manure again. When, however, roots are consumed for the production of milk, a much larger proportion is lost to the manure.

*Table 3 explained.*

The next table (3) shows which constituent, or class of constituents, of the complex material farmyard manure, has the most characteristic influence on the growth of the root-

TABLE 3.—NORFOLK WHITE TURNIPS GROWN YEAR AFTER YEAR ON THE SAME LAND. Results showing the effects of exhaustion and manures, four seasons, 1845-48. Manures and produce per acre per annum.

| | Series 1. No nitrogenous manure. | Series 3. Ammonium-salts=45 lb. nitrogen. | Series 4. Ammonium-salts and rape-cake=135 lb. nitrogen. | Series 5. Rape-cake =90 lb. nitrogen. |
|---|---|---|---|---|
| WITHOUT MINERAL MANURE (THREE YEARS ONLY, 1846-48). | | | | |
| | tons. cwt. | tons. cwt. | tons. cwt. | tons. cwt. |
| Roots . . . | 1 4 | 1 7 | 5 10 | 6 11 |
| Leaves . . . | 0 17 | 1 0 | 3 19 | 3 3 |
| Total . . | 2 1 | 2 7 | 9 9 | 9 14 |
| WITH VARIOUS MINERAL MANURES. | | | | |
| Roots . . . | 8 4 | 9 18 | 10 5 | 11 0 |
| Leaves . . . | 2 14 | 4 6 | 6 3 | 4 12 |
| Total . . | 10 18 | 14 4 | 16 8 | 15 12 |

crop. It shows the average yield over four consecutive seasons, 1845-48, of roots, of leaves, and of total produce, of Norfolk white turnips, grown without manure, and with a variety of artificial manures. The upper division shows the produce without mineral manure, and the lower division the mean produce of different mineral manures—namely (1), superphosphate of lime (plot 5); (2) superphosphate and potash salt (plot 6); (3) superphosphate, and potash, soda, and magnesia salts (plot 4).

*Artificial manures.*

*Produce with artificial manure and without manure.*

The first point to notice is, that on some of the manured plots there is an average of about 11 tons of roots, and more than 4½ tons of leaves, giving of total produce per acre more than 15½ tons. "Without manure," on the other hand, this assumed "restorative crop" yields an average of only 1 ton 4 cwt. of roots, 17 cwt. of leaves, and a total produce of only 2 tons 1 cwt. The character of the unmanured root was, moreover, totally different. It had more the shape of a carrot than of a turnip. Its composition was also totally different from that of the cultivated root, as is strikingly illustrated by the following figures, which relate to the crops of the third season of the experiments, 1845.

*Composition of roots grown with and without manures.*

| | Roots per acre. | | Nitrogen per cent in dry matter. |
|---|---|---|---|
| | tons. | cwt. | per cent. |
| Without manure | 0 | 13¾ | 3.31 |
| Farmyard manure | 17 | 1 | 1.56 |
| Superphosphate of lime | 11 | 2 | 1.52 |

Thus, under the influence of manure there is a very large amount of non-nitrogenous substance accumulated, diluting, so to speak, the high percentage of nitrogen of the natural, uncultivated root. There is indeed also much more nitrogen taken up by the cultivated plant; but in it there is, in proportion to the nitrogen, a large amount of other matters formed, the accumulation of which converts the plant into an important food-crop. Even mineral manures alone, especially those which contain phosphates, have a very marked effect in inducing such accumulation; and it is pre-eminently by the action of such manures that a great amount of fibrous root is developed in the surface-soil, under the influence of which more nitrogen, and at the same time more mineral matters, are taken up.

*Effect of nitrogenous manure.*

The results in the other columns of Table 3 (p. 21) show that the addition of nitrogenous manure, whether as ammo-

nium-salts, or as rape-cake, or both, gives a further increase in the produce of the roots. But the second line of each division of the table shows that a prominent effect of the nitrogenous manures is also largely to increase the production of leaf.

*Leaf and root.* The next Table (4) shows, first, the average proportion of leaf to 1000 of root under the four characteristically different

TABLE 4.—NORFOLK WHITE TURNIPS. Grown year after year on the same land. Mean of plots 4, 5, 6—four years, 1845-1848.

| | | Series 1. Mineral manure alone. | Series 3. Mineral and ammonium-salts =47 lb. nitrogen. | Series 4. Mineral and ammonium-salts and rape-cake =137 lb. nitrogen. | Series 5. Mineral and rape-cake =90 lb. nitrogen. |
|---|---|---|---|---|---|
| **LEAF TO 1000 ROOT.** | | | | | |
| | | 329 | 434 | 600 | 418 |
| **PER CENT.** | | | | | |
| Dry matter | In root | 8.54 | 8.07 | 7.66 | 7.96 |
| | In leaf | 14.56 | 13.54 | 12.43 | 12.94 |
| Nitrogen in dry | In root | 1.60 | 2.64 | 2.45 | 1.78 |
| | In leaf | 3.75 | 3.68 | (3.68) | (3.68) |
| Mineral in dry | In root | 7.26 | 8.22 | 9.03 | 8.30 |
| | In leaf | 12.24 | 11.88 | 11.12 | 11.87 |
| **PER ACRE, LB.** | | | | | |
| Dry matter | In root | 1581 | 1807 | 1770 | 1963 |
| | In leaf | 853 | 1289 | 1703 | 1296 |
| | Leaf+ or − root | −728 | −518 | −67 | −667 |
| Nitrogen | In root | 25 | 48 | 43 | 35 |
| | In leaf | 32 | 48 | 63 | 48 |
| | Leaf+ or − root | +7 | 0 | +20 | +13 |
| Mineral matter | In root | 118 | 148 | 160 | 165 |
| | In leaf | 100 | 151 | 187 | 151 |
| | Leaf+ or − root | −18 | +3 | +27 | −14 |

conditions as to manuring. It also shows the percentages of dry matter in the roots and in the leaves respectively, and the percentages of nitrogen and of total mineral matter (ash) in the dry matter. In the lower division of the table are

given the amounts per acre of each of these constituents, in the roots and leaves respectively, and the amounts per acre, more or less, in the leaf than in the root.

*Effect of manure on leaf and root.*

Thus, with the Norfolk white turnip we have less than one-third as much leaf as root without nitrogenous manure, but nearly two-thirds as much with the largest supply of nitrogen by manure—that is, with the greatest luxuriance of growth.

The economic importance of the difference in the proportion of leaf to root, under the influence of different conditions as to manuring, is illustrated by the other results given in the table; and similar results given in corresponding tables relating to Swedish turnips, sugar-beet, and mangel-wurzel, will show how great is the difference in this respect between different descriptions of root-crops.

In the case of the Norfolk white turnips, not only is there a large proportion of leaf, but the leaf contains a very much higher percentage of dry matter than the root, and there is a very much higher percentage of both nitrogen and total mineral matter in the dry substance of the leaf than in that of the root.

The significance of these facts is more clearly brought out in the lower division of the table, which shows the amounts per acre, in root and in leaf respectively, of dry matter, of nitrogen, and of total mineral matter, under the different conditions of manuring; also the amounts of these in the leaf + or – the amounts in the roots.

It is seen that there was in one case, that with the highest nitrogenous manuring, nearly as much dry or solid matter per acre in the leaf, which for the most part only becomes manure again, as in the edible part of the crop—*the root.* In three cases there is actually more of the nitrogen of the crop in the leaf, remaining for manure, than there is in the portion available as food. There is also, in two cases, more of total mineral constituents in the leaf than in the root.

## 2. *Experiments with Swedish Turnips.*

*Swedes.*

The experiments with the Swedish turnip—*Brassica campestris rutabaga*—were made in the same field, on the same plots, and with to a great extent similar manures, as in the case of the Norfolk white turnips already considered. The mineral manures were in fact practically the same throughout, and the nitrogenous manures were nearly the same in the first two of the four years, 1849 and 1850, but in the second two no nitrogenous manures were used. Further, the results were obtained in the next succeeding four years to those in which the Norfolk whites were grown.

Table 5 shows the average amounts of produce—roots, leaves, and total—under the different conditions of manuring over the four years, two with and two without nitrogenous manures.

TABLE 5.—SWEDISH TURNIPS. Results showing the effects of exhaustion and manures, four seasons, 1849-1852. Manures and produce per acre per annum.

| | Series 1. No nitrogenous manure. | | Series 3. Ammonium-salts=41 lb. nitrogen (1849 and 1850 only). | | Series 4. Ammonium-salts and rape-cake=139 lb. nitrogen (1849 and 1850 only). | | Series 5. Rape-cake =98 lb. nitrogen (1849 and 1850 only). | |
|---|---|---|---|---|---|---|---|---|
| WITHOUT MINERAL MANURE. | | | | | | | | |
| | tons. | cwt. | tons. | cwt. | tons. | cwt. | tons. | cwt. |
| Roots . . . | 2 | 6 | 3 | 17 | 7 | 0 | 7 | 14 |
| Leaves[1] . . . | 0 | 6 | 0 | 6 | 0 | 17 | 0 | 13 |
| Total . . | 2 | 12 | 4 | 3 | 7 | 17 | 8 | 7 |
| WITH VARIOUS MINERAL MANURES (PLOTS 4, 5, AND 6). | | | | | | | | |
| Roots . . . | 7 | 5 | 8 | 18 | 12 | 2 | 11 | 9 |
| Leaves[1] . . . | 0 | 10 | 0 | 11 | 0 | 19 | 0 | 15 |
| Total . . | 7 | 15 | 9 | 9 | 13 | 1 | 12 | 4 |

[1] Average of three years only, 1850-52, leaves in 1849 not weighed.

*Swedes and white turnips compared.* Compared with the produce of the white turnip, that of the Swedish turnip shows upon the whole rather less root without nitrogenous manure—that is, with the mineral manure alone—owing to the gradual exhaustion of the nitrogen of the soil where none had been applied by manure for a number of years. But, on the other hand, there is, with nitrogenous manures, in two cases out of three, more of the Swedish than of the white turnip root.

*Produce of roots and leaves.* A very important point to notice is that there was, even when there was more root, very much less leaf in the case of the Swedish turnip. Thus, whilst with the highest nitrogenous manure there was, with an average of 10¼ tons of the white turnip roots, nearly 6¼ tons of leaves, there was with the Swedish turnip, with more than 12 tons of roots, not quite 1 ton of leaf. Here, then, the result of growth is that almost the whole of the accumulation is in the food-product, the root, and a very insignificant amount remains in the leaf, most of it simply to become manure again. *Accumulation in the root.*

*Table 6 explained.* This point will be more clearly illustrated by the results given in Table 6, which gives the leaf to 1000 root, and the

same particulars as before relating to the percentage composition of each, and to the amounts of the selected constituents *per acre* in each.

TABLE 6.—SWEDISH TURNIPS. Proportion of leaf to root, and selected constituents in root and leaf, per cent and per acre. Mean of plots 4, 5, and 6; four years, 1849-52.

| | | Series 1. Mineral manure alone. | Series 3. Mineral and ammonium-salts=41 lb. nitrogen. | Series 4. Mineral and ammonium-salts and rape-cake=180 lb nitrogen. | Series 5. Mineral and rape-cake=98 lb. nitrogen. |
|---|---|---|---|---|---|
| **LEAF TO 1000 ROOT.** | | | | | |
| | | 69.0 | 61.8 | 78.5 | 65.5 |
| **PER CENT.** | | | | | |
| Dry matter | In root . . | 11.59 | 11.51 | 10.54 | 10.89 |
| | In leaf . . | 13.81 | 13.08 | 12.97 | 13.19 |
| Nitrogen in dry | In root . . | 1.40 | 1.69 | 2.19 | 1.84 |
| | In leaf . . | 3.95 | 4.07 | 4.11 | 4.00 |
| Mineral matter in dry | In root . . | 4.38 | 4.49 | 4.83 | 4.66 |
| | In leaf . . | 12.16 | 11.85 | 10.54 | 10.59 |
| **PER ACRE, LB.** | | | | | |
| Dry matter | In root . . | 1879 | 2245 | 2840 | 2769 |
| | In leaf . . | 154 | 166 | 270 | 227 |
| | Leaf + or − root | −1725 | −2079 | −2570 | −2542 |
| Nitrogen | In root . . | 26 | 38 | 62 | 51 |
| | In leaf . . | 6 | 7 | 11 | 9 |
| | Leaf + or − root | − 20 | − 31 | − 51 | − 12 |
| Mineral matter | In root . . | 83 | 102 | 139 | 130 |
| | In leaf . . | 19 | 20 | 29 | 24 |
| | Leaf + or − root | − 64 | − 82 | − 110 | − 106 |

*Proportions of leaf and root.*

It is seen that instead of 300 to 600 parts of leaf for 1000 of root, as in the white or common turnip, we have, with the Swedish turnip, in no case 100 of leaf to 1000 of root. The highest proportion is 78½ to 1000, and this is with the highest nitrogenous manuring, and the most luxuriant crops.

It is further seen that the percentage of dry matter in the root ranged from 10½ to 11½, whilst in the white turnip it averaged only about 8 per cent. We have, therefore, not

only a larger proportion of edible root, but that root contains a larger proportion of solid matter or food-material.

*Composition of roots and leaves of Swedes and white turnips.*

As with the Norfolk white, however, so also with the Swedish turnip, the leaf contains a much higher percentage of dry substance than the root, and the dry substance of the leaf contains a much higher percentage of both nitrogen and total mineral matter than does the dry substance of the root.

The lower division of the table shows, when compared with the corresponding particulars relating to the Norfolk white turnip, that with the Swedish turnip there was, with the highest manuring, fully one and a-half time as much dry substance per acre in the root—that is, one and a-half time as much food produced per acre as with the common turnip.

Further, there is a quite insignificant amount of matter accumulated and remaining in the leaf, for the most part only serving as manure again.

Of the nitrogen, again, there is, under all conditions of manuring, even those giving the greatest luxuriance, a very small proportion remaining in the leaf. The same is the case with the total mineral matter.

*Superiority of Swedes.*

The question obviously suggests itself, If the Swedish turnip has all these advantages over the numerous varieties of the so-called common turnip, why are these ever grown? why not always the Swedish turnip?

*Why other varieties are grown.*

In the first place, soil and season have to be taken into account. Then the economy of the farm requires that descriptions should be selected that can not only be sown in due succession, but which will mature at different periods, so as to supply food for stock in due succession, and also frequently to get the crop early off the land, to leave it free for some other crop. Again, a comparatively large proportion of leaf serves as protection against frost while the crop is still in the field; and the storing qualities of the root have to be considered in connection with the character of the seasons of the locality. For example, on the light soils of Norfolk, which are very favourable for the development of root, and but little for that of leaf, and where the roots can be largely consumed by sheep on the land without injury to its mechanical condition, the Swedish turnip is the predominant root. In the north-east and east of Scotland, on the other hand, several varieties of yellow common turnips are grown in much larger proportion, and a large amount of leaf is not recognised as a disadvantage.

*Production and economy of leaf.*

And here it may be observed that, the higher the nitrogenous manuring, and the heavier the soil, the greater is the tendency to produce a large amount of leaf. Further, as a rule the larger the amount of leaf remaining vigorous at the time the crop is taken up, the less

fully ripe will be the roots; and within limits it is desirable, with a view to the storing qualities of the root, that it should not be too ripe.

*Accumulation from rape-cake.*

After the four crops of Swedish turnips had been taken from the land, barley was grown for three years in succession without any manure, in order as far as possible to equalise the condition of the various plots, as affected by the previous manuring. It will suffice to say that the results clearly showed that there had been accumulation where rape-cake had been applied.

Then for five years in succession (1856-60) Swedish turnips were again grown on the comparatively exhausted plots, much on the same plan as before, but with smaller amounts of nitrogen supplied. No special interest attaches to the results over these five years for our present purpose.

Table 7 shows the average produce per acre over the next ten years, 1861-70, again with Swedish turnips.

*Further trials with Swedes.*

During this period larger quantities of nitrogen were again applied, but for mineral manure superphosphate of lime was used alone—that is, without any further addition of either potash, soda, or magnesia.

TABLE 7.—SWEDISH TURNIPS. Results showing the effects of exhaustion and manures. Mean of ten seasons, 1861-70. Manures and produce per acre per annum.

| | Series 1. No nitrogenous manure | | Series 2. Sodium nitrate =82 lb nitrogen. | | Series 3. Ammonium-salts= 82 lb. nitrogen | | Series 4. Ammonium salts and rape cake =180 lb. nitrogen. | | Series 5 Rape-cake =98 lb nitrogen | |
|---|---|---|---|---|---|---|---|---|---|---|
| WITHOUT MINERAL MANURE | | | | | | | | | | |
| | tons | cwt. | tons. | cwt | tons | cwt | tons. | cwt. | tons. | cwt. |
| Roots . . . | 0 | 11 | 1 | 1 | 0 | 13 | 4 | 9 | 4 | 15 |
| Leaves . . . | 0 | 3 | 0 | 5 | 0 | 3 | 1 | 0 | 0 | 18 |
| Total . . | 0 | 14 | 1 | 6 | 0 | 16 | 5 | 9 | 5 | 13 |
| WITH SUPERPHOSPHATE OF LIME (PLOTS 4, 5, AND 6) | | | | | | | | | | |
| Roots . . . | 2 | 9 | 5 | 8 | 4 | 9 | 7 | 9 | 6 | 8 |
| Leaves . . . | 0 | 9 | 1 | 0 | 0 | 17 | 1 | 14 | 1 | 3 |
| Total . . | 2 | 18 | 6 | 8 | 5 | 6 | 9 | 3 | 7 | 11 |

*Former results confirmed.*

The results of these experiments are little more than confirmatory of those which have gone before, but the amounts of produce are throughout on a lower level. This can only in part be attributed to the exclusion of potash from the manures. It is doubtless mainly due to the incidental circumstance that in growing the same description of crop, with the

same comparatively limited and superficial root-range, for so many years in succession, the surface-soil became less easily worked, and the tilth, so important for turnips, was frequently unsatisfactory; whilst for want of variety and depth of root-range of the crop a somewhat impervious pan was formed below.

*Reduction in produce caused by continuous root-culture.*

The fact is, however, of itself of considerable interest, as indicating one important and very beneficial influence of a rotation of crops. Indeed, we shall presently see that even the change to another description of root-crop, with a totally different and much more extended root-range, is accompanied with a much increased production over a given area by the use of the same manures.

*Nitrate of soda and ammonium-salts compared.*

Looking to the Table (7), it is seen that there are now five series of plots instead of only four, nitrate of soda being applied on Series 2, in amount supplying the same quantity of nitrogen as in the ammonium-salts on Series 3. The result is a greater produce of both root and leaf than with the ammonium-salts.

*Superphosphate.*

The superphosphate alone (see lower division of column 1) gives much less produce than the mineral manures in the series of four years before considered, doubtless to a great extent owing to the still further exhaustion of the available nitrogen of the surface-soil. In fact the surface-soils in question showed, on analysis, lower percentages of nitrogen than those of any other experimental field at Rothamsted — a result which is quite consistent with the fact of the large amount of root distributed through the surface-soil by the growing turnip.

*Nitrogenous manures.*

Again, consistently with this supposition, and with the results that have gone before, there is still very marked but somewhat reduced effect from all the nitrogenous manures; and again, the amount of leaf is very small, but it is the greater the higher the nitrogenous manuring, and the greater the luxuriance of growth.

*Table 8 explained.*

Table 8 shows the proportion of leaf to 1000 of root; also the percentages of dry matter, and of nitrogen and mineral matter in the dry matter; and, as before, the amounts of each per acre, in the roots and in the leaves.

*Proportions of leaf and root.*

With the soil gradually becoming closer, and less favourable for root-development, the proportion of leaf to root is somewhat higher.

It should be explained that the percentages given in parenthesis are not the results of direct determinations in each particular case, but are deduced from comparable results. They are, however, undoubtedly near enough to the truth for the purpose of the present illustrations.

*Composition of leaf and root.*

Again, we see much higher percentage of dry substance in the leaf than in the root; also much higher percentages of nitrogen, and of total mineral matter, in the dry substance of the leaf.

TABLE 8.—SWEDISH TURNIPS. Means of plots 4, 5, and 6; ten years, 1861-1870.

| | | Series 1. Mineral manure alone. | Series 2. Mineral and sodium nitrate =82 lb. nitrogen. | Series 3. Mineral and ammonium-salts =82 lb. nitrogen. | Series 4. Mineral and ammonium-salts and rape-cake =180 lb. nitrogen. | Series 5. Mineral and rape-cake =98 lb. nitrogen. |
|---|---|---|---|---|---|---|
| **LEAF TO 1000 ROOT.** | | | | | | |
| | | 184 | 185 | 191 | 228 | 180 |
| **PER CENT.** | | | | | | |
| Dry matter | In root | 12.04 | 11.01 | 11.32 | 10.94 | 10.83 |
| | In leaf | 14.93 | 14.46 | 14.24 | 13.78 | 14.66 |
| Nitrogen in dry | In root | (1.40) | (1.69) | (1.69) | (2.19) | (1.84) |
| | In leaf | (3.95) | (4.07) | (4.07) | (4.11) | (4.00) |
| Mineral matter in dry | In root | 4.55 | 5.38 | 4.71 | 5.10 | 5.03 |
| | In leaf | 11.64 | 10.62 | 12.23 | 11.54 | 11.27 |
| **PER ACRE, LB.** | | | | | | |
| Dry matter | In root | 629 | 1285 | 1084 | 1777 | 1511 |
| | In leaf | 146 | 320 | 268 | 498 | 376 |
| | Leaf + or − root | −483 | −965 | −816 | −1279 | −1135 |
| Nitrogen | In root | 8.8 | 21.7 | 18.3 | 38.9 | 27.8 |
| | In leaf | 5.8 | 13.0 | 10.9 | 20.5 | 15.1 |
| | Leaf + or − root | −3.0 | −8.7 | −7.4 | −18.4 | −12.7 |
| Mineral matter | In root | 28.9 | 71.1 | 53.6 | 94.2 | 76.6 |
| | In leaf | 16.8 | 33.1 | 32.5 | 57.5 | 41.9 |
| | Leaf + or − root | −12.1 | −38.0 | −21.1 | −36.7 | −34.7 |

Looking to the lower division of the table, it is seen that there is here again, under all conditions of manuring, much more solid matter per acre in the root than in the leaf. There is also more nitrogen, and more total mineral matter, accumulated in the root; though the proportion of the nitrogen which is accumulated in the leaf is higher than in the previous experiments.

### 3. *Experiments with Sugar-beet.*

*Sugar-beet.* To the Order Chenopodiaceæ, and to the species *Beta vulgaris,* we owe many varieties of sugar-beet, and also many varieties of feeding-beet or mangel-wurzel. Mangel-wurzel is a very important agricultural crop in some localities of our own country, whilst sugar-beet is not. Trials have, however, been made on the growth of sugar-beet for the production of sugar; and as we have experimented on the subject, we will in the first place illustrate the influence of various manures on the growth of the crop, and on the production of sugar in it; and afterwards, in more detail, give somewhat similar results relating to the mangel.

The experiments with both crops were made in the same field and on the same plots as those on which first Norfolk whites and afterwards Swedish turnips had been grown. The last crop of Swedish turnips was taken in 1870, and sugar-beet then followed for five years in succession, 1871-75 inclusive. Experiments with the mangel were then commenced in 1876, and have been continued up to the present time, so that the crop of 1894 was the nineteenth in succession. It has been stated that by the continuous growth of the one description of crop, the Swedish turnip, with one character and limited range of roots, the surface-soil had become close, and a somewhat impervious pan was formed below it. Therefore before growing sugar-beet the land was ploughed more deeply.

*Plan of experiment.* During the first three of the five years of sugar-beet, the arrangement of the plots and of the manures was substantially the same as afterwards for mangels; but during the last two years of the five, neither farmyard nor any other nitrogenous manure was applied, the object being to determine the effects of the unexhausted residue of the nitrogenous applications during the preceding three years.

*Characteristic growth of sugar-beet.* Sugar-beet has a very much more deeply penetrating root than the turnip, and more even than the feeding-beet or mangel. In fact, great command of the resources of the soil and subsoil is a characteristic of the cultivated plant. The root found to give the highest percentage of sugar is very characteristically fusiform; and by careful selection of plants from which to grow seed, varieties are obtained nearly the whole of the swollen root of which forms under the surface of the soil — the percentage of sugar being much lower in the above-ground portion exposed to light. To such perfection has the art of selection, cultivation, and acclimatisation reached, that some descriptions, when grown

in suitable soils and localities, will yield nearly, and sometimes quite, 20 per cent of sugar!

*Produce from dung alone and from dung and other manures.*

For brevity, and as such heavy manuring is not adopted for the growth of beet for the manufacture of sugar, the results obtained with farmyard manure will not be given in any detail. It may, however, be observed that over the three years of the application, the average produce per acre of roots of farmyard manure alone was about 16 tons, which was raised to nearly 24 tons by the annual addition of 86 lb. of nitrogen per acre as nitrate of soda; to about 22 tons by the same quantity of nitrogen as ammonium-salts; to nearly 25 tons by 98 lb. of nitrogen as rape-cake; and to more than 25 tons by 184 lb. as rape-cake and ammonium-salts together. These facts are sufficient to show how powerful a feeder and grower is the sugar-beet when liberally manured; and that, provided other supplies are not deficient, nitrogenous manures very greatly increase the produce.

*Table 9 explained.*

The following Table (9, p. 33) shows the average produce of sugar-beet; in detail roots only, and in the summary roots and leaves, over the three years, the two years, and the five years, under three conditions of mineral manuring, each alone, and each cross-dressed as indicated, by various nitrogenous manures.

*Artificial manures.*

The table shows that when superphosphate was used either without nitrogenous manure or with nitrate of soda, the produce was as great as when potash was applied in addition; but when the nitrogen was applied as ammonium-salts, ammonium-salts and rape-cake, or rape-cake, the addition of potash to the superphosphate shows more effect. And it will be seen further on, that in the case of the mangels in subsequent years, the effect of the potash was very much more marked—that is, when under the continuous use of superphosphate without potash, the potash of the soil had doubtless become more and more exhausted. That the deficiency of produce is much less marked where the superphosphate is applied with nitrate of soda than where with ammonium-salts or rape-cake, is probably due to the roots of the plant penetrating more deeply under the influence of the more soluble and more rapidly distributed nitrate with its more readily available nitrogen—thus securing a better command of the supplies of potash (and other constituents) in the lower layers of the soil and subsoil.

*Produce from mineral manures alone and with addition of nitrogenous manures.*

Turning to the summary at the foot of the table, which gives the average results over the three years for plots 6 and 4 (with potash supply) both without and with nitrogenous manures, it is seen that whilst the mineral manures alone give an average of less than 6 tons of roots, the addition of

TABLE 9.—SUGAR-BEET. Results showing the effects of exhaustion and manures. Manures and produce per acre per annum.

| Plot | Standard manures. | Series 1. Standard manures only. | | Standard manures, and— Series 2 Sodium nitrate = 86 lb. nitrogen | | Series 3. Ammonium-salts = 86 lb nitrogen | | Series 4 Ammonium-salts and rape-cake = 184 lb. nitrogen. | | Series 5 Rape-cake = 98 lb nitrogen. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MEAN OF 3 YEARS, 1871-73, WITH NITROGENOUS MANURES (ROOTS ONLY)** | | | | | | | | | | |
| | | tons | cwt | tons. | cwt. | tons. | cwt | tons. | cwt | tons. | cwt |
| 5 | Superphosphate . . | 5 | 18 | 19 | 11 | 13 | 9 | 17 | 15 | 16 | 5 |
| 6 | Superphosphate and potassium sulphate | 5 | 6 | 17 | 19 | 14 | 16 | 22 | 3 | 17 | 4 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 6 | 9 | 19 | 15 | 15 | 3 | 22 | 2 | 18 | 9 |
| | **MEAN OF 2 YEARS, 1874 & 1875, WITHOUT NITROGENOUS MANURES (ROOTS ONLY).** | | | | | | | | | | |
| 5 | Superphosphate . . | 5 | 15 | 8 | 15 | 7 | 11 | 10 | 16 | 8 | 9 |
| 6 | Superphosphate and potassium sulphate | 5 | 8 | 8 | 3 | 7 | 11 | 10 | 19 | 8 | 17 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 5 | 19 | 9 | 2 | 7 | 13 | 11 | 13 | 9 | 3 |
| | **MEAN OF 5 YEARS, 1871-75 (ROOTS ONLY).** | | | | | | | | | | |
| 5 | Superphosphate . . | 5 | 17 | 15 | 4 | 11 | 2 | 14 | 19 | 13 | 3 |
| 6 | Superphosphate and potassium sulphate | 5 | 7 | 14 | 1 | 11 | 19 | 17 | 14 | 13 | 17 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 6 | 5 | 15 | 10 | 12 | 3 | 17 | 18 | 14 | 14 |
| | **SUMMARY—MEAN OF PLOTS 6 & 4 (ROOTS AND LEAVES).** | | | | | | | | | | |
| Mean of 3 years, 1871-73 | Roots . . | 5 | 18 | 18 | 17 | 14 | 19 | 22 | 3 | 17 | 17 |
| | Leaves . | 1 | 7 | 5 | 2 | 3 | 10 | 7 | 16 | 3 | 13 |
| | Total . . | 7 | 5 | 23 | 19 | 18 | 9 | 29 | 19 | 21 | 10 |
| Mean of 2 years, 1874 and 1875 | Roots . . | 5 | 14 | 8 | 13 | 7 | 12 | 11 | 6 | 9 | 0 |
| | Leaves . . | 1 | 3 | 2 | 2 | 1 | 10 | 3 | 6 | 2 | 8 |
| | Total . . | 6 | 17 | 10 | 15 | 9 | 2 | 14 | 12 | 11 | 8 |
| Mean of 5 years, 1871-75 | Roots . . | 5 | 16 | 14 | 15 | 12 | 1 | 17 | 16 | 14 | 5 |
| | Leaves . . | 1 | 6 | 3 | 18 | 2 | 14 | 6 | 0 | 3 | 3 |
| | Total . . | 7 | 2 | 18 | 13 | 14 | 15 | 23 | 16 | 17 | 8 |

nitrate of soda raises the produce to nearly 19 tons, that of ammonium-salts to nearly 15 tons, that of rape-cake to nearly 18 tons, and that of rape-cake and ammonium-salts together to more than 22 tons. It is also seen that during the succeeding two years, when no further nitrogenous manure was used, there was still more or less increase, due partly to the manure-residue of the previous applications, and partly to the increased amount of leaf that had been annually returned to the land as manure where nitrogenous manures had been employed. Thus the average produce over the two years by the mineral manures, including potash, but without nitrogenous manure, was 5 tons 14 cwt., raised where nitrate of soda had previously been applied to 8 tons 13 cwt., where ammonium-salts had been used to 7 tons 12 cwt., where rape-cake to 9 tons, and where rape-cake and ammonium-salts together to 11 tons 6 cwt.

*Produce of leaf.* The summary further shows that over the three years of the application of nitrogenous manures, the produce of leaf was raised from 1 ton 7 cwt. with the mineral manures alone, to 5 tons 2 cwt. by the addition of sodium nitrate, to 3 tons 10 cwt. by ammonium-salts, to 3 tons 13 cwt. by rape-cake, and to 7 tons 16 cwt. by rape-cake and ammonium-salts together. Over the next two years, without further nitrogenous manuring, but with some nitrogenous manure-residue, and increased return of leaf to the land, where nitrogenous manures had been applied, the produce of leaf was raised from 1 ton 2 cwt. by the mineral manure alone, to 2 tons 2 cwt. where in addition nitrate of soda had previously been applied, to 1 ton 10 cwt. where ammonium-salts had been used, to 2 tons 8 cwt. where rape-cake, and to 3 tons 6 cwt. where rape-cake and ammonium-salts had been applied together.

*Table 10 explained.* The next Table (10, p. 35) which relates to the mean produce of plots 6 and 4 (with potash), over the three years during which the nitrogenous manures were annually applied, shows the proportion of leaf to 1000 of root, some particulars of the percentage composition of the root, and of the leaf, and the amounts of certain constituents per acre in the root and in the leaf.

*Proportions of leaf and root.* The first line of figures shows a range of from 205 to 354 parts of leaf to 1000 of root, according to the manure, and the consequent degree of luxuriance and of maturity. The proportion of leaf was thus much higher than in Swedish turnips; it is also higher than in mangel-wurzel, but much lower than in common turnips.

*Composition of leaf and root.* The percentage of dry matter in the root is more than twice as high as in common turnips, more than one and a-half

TABLE 10.—SUGAR-BEET. Mean of plots 6 and 4; 3 years, 1871-73.

| | | Series 1. Mineral manure alone. | Series 2. Mineral and sodium nitrate =86 lb. nitrogen. | Series 3. Mineral and ammonium-salts =86 lb. nitrogen. | Series 4. Mineral and ammonium-salts and rape-cake =184 lb. nitrogen. | Series 5. Mineral and rape-cake =98 lb. nitrogen. |
|---|---|---|---|---|---|---|
| **LEAF TO 1000 ROOT.** | | | | | | |
| | | 230 | 269 | 232 | 354 | 205 |
| **PER CENT.** | | | | | | |
| Dry matter | In root . . | 18.75 | 16.83 | 18.16 | 17.04 | 17.88 |
| | In leaf . . | 14.65 | 11.19 | 12.12 | 10.20 | 11.28 |
| Nitrogen in dry | In root . . | 0.58 | 0.95 | 0.84 | 1.27 | 0.82 |
| | In leaf . . | 2.18 | 2.61 | 2.30 | 2.76 | 2.34 |
| Mineral matter in dry | In root . . | 4.11 | 5.13 | 4.75 | 5.59 | 4.54 |
| | In leaf . . | 23.83 | 22.13 | 23.47 | 22.08 | 22.86 |
| Potash in dry | In root . . | 1.45 | 1.67 | 1.72 | 1.84 | 1.61 |
| | In leaf . . | 5.29 | 4.52 | 4.82 | 4.58 | 5.21 |
| Phosphoric acid in dry | In root . . | 0.57 | 0.55 | 0.52 | 0.57 | 0.56 |
| | In leaf . . | 0.78 | 0.67 | 0.64 | 0.62 | 0.81 |
| **PER ACRE, LB.** | | | | | | |
| Dry matter | In root . . | 2463 | 6996 | 6086 | 8444 | 7096 |
| | In leaf . . | 435 | 1248 | 934 | 1768 | 925 |
| | Leaf + or − root | −2028 | −5748 | −5152 | −6676 | −6171 |
| Nitrogen . | In root . . | 14.3 | 67.0 | 51.2 | 105.5 | 58.4 |
| | In leaf . . | 9.5 | 32.8 | 21.5 | 48.8 | 21.6 |
| | Leaf + or − root | −4.8 | −34.2 | −29.7 | −56.7 | −36.8 |
| Mineral matter | In root . . | 101.2 | 364.2 | 288.5 | 469.6 | 322.1 |
| | In leaf . . | 103.7 | 276.9 | 217.9 | 390.0 | 210.2 |
| | Leaf + or − root | +2.5 | −87.3 | −70.6 | −79.6 | −111.9 |
| Potash . | In root . . | 35.6 | 117.1 | 104.4 | 155.1 | 113.9 |
| | In leaf . . | 23.0 | 56.4 | 45.0 | 81.0 | 48.2 |
| | Leaf + or − root | −12.6 | −60.7 | −59.4 | −74.1 | −65.7 |
| Phosphoric acid | In root . . | 14.1 | 38.8 | 31.5 | 48.3 | 39.4 |
| | In leaf . . | 3.4 | 8.3 | 6.0 | 11.0 | 7.5 |
| | Leaf + or − root | −10.7 | −30.5 | −25.5 | −37.3 | −31.9 |

time as high as in swedes, and considerably higher than in the feeding-beet or mangel-wurzel. It will afterwards be seen that this increased amount of solid matter in the root is chiefly sugar.

As in the case of the mangel leaf, the percentage of dry matter in the sugar-beet leaf is actually lower than in the case of the turnips; and it is very much lower than in the sugar-beet root, whilst in the turnip it was very much higher in the leaf than in the root.

The percentage of nitrogen in the dry substance of the root is much lower than in the case of the turnip; and it is in a less degree lower than in the mangel-root grown by the same manures. As in the case of the other descriptions of roots, the percentage of nitrogen in the dry matter of the sugar-beet leaf is very much higher than in that of the root.

The percentage of mineral matter in the dry substance of the leaf is four or five times as high as that in the root; in fact the mineral matter constitutes more than one-fifth of the total dry substance of the leaf. It is higher than in the case of the mangels, and about twice as high as in that of either Swedish or common turnips.

To determine the amounts of potash and phosphoric acid in the root and in the leaf, respectively, of both sugar-beet and mangel-wurzel a large series of analyses of the ashes of the root and of the leaf of the experimentally grown sugar-beet and mangel-wurzel, has been made. Table 10 (p. 35) shows that the percentage of potash in the dry matter of the sugar-beet leaf is very much higher than in that of the root. Of phosphoric acid, on the other hand, the percentage in the dry matter of the leaf is but little higher than in that of the root; whilst in the dry matter of both root and leaf it is very much lower than is that of potash.

*Effect of manures on leaf and root.*

The lower division of the table shows that, notwithstanding the comparatively large proportion of fresh leaf to root, the proportion of the total solid matter of the crop which is accumulated and remains in the leaf is, owing to the very high percentage of solid matter in the root and very much lower percentage in the leaf, much less than would be concluded from the weight of the fresh produce only. Thus, with the lowest proportion of leaf, as in Series 5 with rape-cake, there was more than 3 tons per acre of solid matter in the root, and much less than half a ton in the leaf; whilst with the highest nitrogenous manuring, the greatest luxuriance, the heaviest crops, and the highest proportion of leaf to root, as in Series 4 with rape-cake and ammonium-salts together, there are more than 3¾ tons of solid matter per acre in the root, and little more than ¾ ton in the leaf. It

will be seen further on how large a proportion of the solid matter of the root of this highly artificial vegetable produce is *sugar*.

The lower division of the table further shows that, whilst there was only 14.3 lb. of nitrogen per acre in the roots without nitrogenous supply, the amount was raised—by nitrate of soda to 67 lb., by ammonium-salts to 51.2 lb., by rape-cake to 58.4 lb., and by rape-cake and ammonium-salts together to 105.5 lb. Then the amount of nitrogen per acre in the leaf was—with mineral but without nitrogenous manure 9.5 lb., with the addition of nitrate of soda 32.8 lb., of ammonium-salts 21.5 lb., of rape-cake 21.6 lb., and of rape-cake and ammonium-salts together 48.8 lb. A point of interest in regard to the amounts of nitrogen per acre in the crops is, however, that there was in every case very much more accumulated in the root than in the leaf, which is chiefly of value only as manure again.

It is further seen that with the same mineral, but varying nitrogenous supply, the amount of total mineral matter per acre in the roots was—only 101.2 lb. without nitrogen supply, 364.2 lb. with nitrate of soda, 288.5 lb. with ammonium-salts, 322.1 lb. with rape-cake, and 469.6 lb., or more than 4 cwt., with the rape-cake and ammonium-salts together. Lastly, the total amount of mineral matter per acre in the leaf was, with the very high percentage in the dry substance, very large; but it was in each case, with nitrogenous supply, considerably less in the leaf than in the root. It is remarkable that with the same mineral supply in each case there was, without nitrogen, less than 2 cwt. of mineral matter per acre per annum in root and leaf together, whilst with the highest nitrogenous supply in addition there was nearly 7¾ cwt. of mineral matter in the total crop. There is here evidence both of how liberal must be the supply of available mineral constituents for the luxuriant growth of the crop, and how great will be the exhaustion of them if the crop be sold off the farm.

***Nitrogen and potash and sugar-production.***

Bearing in mind that the same amount of potash was applied per acre in the case of each of the five series, it is of interest to observe that the percentage of potash in the dry substance of the root was distinctly higher in the four series with nitrogenous supply than in Series 1 without it; and when we consider, as will be fully illustrated further on, that the amount of sugar produced depends very materially on the amount of nitrogen taken up, and that a liberal supply of available potash has also much influence on the amount of sugar produced, it is what might be expected that, with liberal nitrogen-supply and increased production of sugar, we

should find an increased amount of potash taken up. In fact, the lower division of the table shows that, with the same potash supply by manure, there was, compared with the amount stored in the root without nitrogenous supply, more than three times as much where nitrate of soda was added, nearly three times as much where ammonium-salts were used, about three times as much where rape-cake was employed, and nearly four and a-half times as much where rape-cake and ammonium-salts were applied together, supplying an excessive amount of nitrogen. The actual amounts of potash per acre in the roots were indeed—only 35.6 lb. per acre per annum without nitrogenous supply, 117.1 lb. with nitrate of soda, 104.4 lb. with ammonium-salts, 113.9 lb. with rape-cake, and 155.1 lb. with the excessive supply of nitrogen in ammonium-salts and rape-cake together.

Although, as has been seen, the percentage of potash was very much higher in the dry substance of the sugar-beet leaf than in that of the root, the figures in the lower division of the table show that under all conditions as to nitrogenous supply there was much less potash per acre in the leaf than in the root. As, however, the leaf would be returned to the land as manure, there should be no loss of the potash of the farm by the amount of it left in the leaf. And again, as the very much larger amount of potash in the roots should, when consumed on the farm, be almost wholly recovered in the manure of the animals fed upon them, there should be but little loss to the farm of the potash they contained. If, however, either the roots or the leaves are removed or sold off the farm, the exhaustion of potash may be very considerable.

*Phosphoric acid in root and leaf.*

Turning to the amounts of phosphoric acid, the supply of which was the same for each of the five series, it has been seen that the percentage of it in the dry substance of the roots varied comparatively little; but the figures in the lower division of the table show that the actual quantities per acre in the roots varied very considerably, and to a great extent in proportion to the amounts of growth as influenced by the nitrogenous supply. It is further seen that the amounts of phosphoric acid remaining in the leaf are very small compared with those in the root.

*Produce from direct manuring and residue-action.*

It has already been shown when considering the results recorded in Table 9 (p. 33) relating to the selected artificially-manured plots, that the produce over the two years after the cessation of the application of the nitrogenous manures indicated considerable increase over that where no nitrogen had been applied, due partly to the residue of the nitrogenous manures previously applied, and partly to the residue (leaves, &c.) of the larger crops previously grown. It will be of interest here to show the average produce of roots per acre per

annum on the different divisions of the farmyard manure plot over the three years of the direct application of the manures, and over the succeeding two years of manure- and crop-residue. It was as follows:—

TABLE 11.

| | Series 1. Farmyard manure alone (3 years only) | | Farmyard manure, and— Series 2. Sodium nitrate =86 lb nitrogen (3 years only) | | Series 3. Ammonium-salts =86 lb nitrogen (3 years only). | | Series 4. Ammonium-salts and rape-cake=184 lb. nitrogen (3 years only). | | Series 5. Rape-cake =98 lb. nitrogen (3 years only). | |
|---|---|---|---|---|---|---|---|---|---|---|
| | tons. | cwt. | tons. | cwt. | tons. | cwt. | tons. | cwt. | tons. | cwt. |
| 3 years of direct application | 16 | 6 | 23 | 16 | 22 | 6 | 25 | 2 | 24 | 18 |
| 2 years of residue of manure and crop | 14 | 0 | 15 | 16 | 16 | 3 | 17 | 17 | 17 | 2 |
| Difference | 2 | 6 | 8 | 0 | 6 | 3 | 7 | 5 | 7 | 16 |

Thus there was an average of little more than 2¼ tons of roots per acre per annum less over the two years of unexhausted residue of the farmyard manure than over the three years of its direct application. There was also less leaf over the two years of residue. It is seen, however, that on the divisions of the farmyard-manure plot, where artificial nitrogenous manures were used in addition, there was an average of from 7 to 8 tons of roots less over the two years of residue than previously. There was also considerable reduction in the produce of leaf. Still the greater produce over the two years of residue-action, where the nitrogenous manures had been previously used in addition than where the farmyard manure had been used alone, show considerable effect from the residue either of the artificial nitrogenous manures themselves, or from their increased crop-residue; and so far as there is any direct effect from the manure-residue of the previously applied nitrate or ammonium-salts, it is probably chiefly due to nitrates being drawn up again from the subsoil. Even in the case of the rape-cake, the residue-effect is also doubtless largely due to crop-residue, but to a considerable degree to manure-residue also—a portion of the nitrogenous matter of such organic manures becoming very slowly available in the soil.

*Manure-residue and crop-residue.*

To sum up on this point: In the case of the nitrate and ammonium-salts, the effect of residue will be in the least proportion due to manure-residue, and in the greatest to crop-residue. With such manures as rape-cake, the effect will be due in a large proportion to manure-residue, and also largely to

crop-residue. With farmyard manure, so far as there had been larger crops, there will be much crop-residue; but a very large proportion of the effect on future crops is to be attributed to slowly decomposing manure-residue.

*Table 12 explained.* The next Table (12) shows for the produce of the two years without further application of nitrogenous manures, the same particulars as to composition as Table 10 for the preceding three years—namely, the amount of leaf to 1000 root, and the percentages, and the amounts per acre, of certain constituents in the root and in the leaf. The results need not be considered in much detail.

*Leaf and root.* Excepting in the case of Series 5, the proportion of leaf to root is considerably less over the two years, with the less supply of nitrogen within the soil, and the consequent much less luxuriance. There is, nevertheless, over the two years a lower percentage of dry substance in the root, doubtless owing to the less formation of sugar with the less nitrogen available to the plant. There is also generally a somewhat lower percentage of dry or solid substance in the leaf over the two years of comparative exhaustion. Again, there is, where nitrogenous manures had previously been applied, generally a lower, and in some cases a considerably lower, percentage of nitrogen in the dry substance of the roots over the two years of only residual supply. The percentage of nitrogen in the dry substance of the roots is indeed very low over both periods, but especially in the second; and it will be seen further on that it is much lower than in either of the descriptions of roots cultivated for feeding purposes. In fact, so much is the sugar-forming habit of the plant developed, and so largely does the amount of the non-nitrogenous substance —*sugar*—contribute to the percentage of dry matter, that the percentage of the nitrogenous bodies is relatively very low, even though a large amount of nitrogen may have been taken up over a given area. As in the case of the three years with direct nitrogenous manures, so now over the two years with only residual supply of nitrogen, the percentage of nitrogen in the dry substance of the leaf is very much higher than in that of the root. It is, however, in each series somewhat higher over the two years than over the three of direct supply, perhaps owing to somewhat less matured—that is less exhausted—condition of the leaves over the two years.

Turning now to the percentage of total mineral matter in the dry substance over the two years, it is seen that in the root and leaf respectively it is approximately the same over the two years as over the preceding three; and it is as was the case over the three years, four or five times as high in the dry substance of the leaf as in that of the root.

TABLE 12.—SUGAR-BEET. Mean of plots 6 and 4; 2 years, 1874-75.

| | | The mineral manures, every year, and— | | | | |
|---|---|---|---|---|---|---|
| | | Series 1. (No nitrogenous manure). | Series 2. (Previously sodium-nitrate). | Series 3. (Previously ammonium-salts). | Series 4. (Previously ammonium-salts and rape-cake) | Series 5. (Previously rape-cake). |
| **LEAF TO 1000 ROOT.** | | | | | | |
| | | 206 | 248 | 197 | 294 | 263 |
| **PER CENT.** | | | | | | |
| Dry matter | In root . . | 17.77 | 15.71 | 16.67 | 16.31 | 16.01 |
| | In leaf . . | 11.21 | 10.18 | 11.41 | 10.45 | 10.24 |
| Nitrogen in dry | In root . . | 0.66 | 0.71 | 0.84 | 0.87 | 0.80 |
| | In leaf . . | 2.47 | 2.65 | 2.61 | 2.85 | 2.74 |
| Mineral matter in dry | In root . . | 4.27 | 5.15 | 4.94 | 5.37 | 5.41 |
| | In leaf . . | 22.05 | 22.64 | 21.30 | 21.01 | 22.14 |
| Potash in dry | In root . . | 1.56 | 1.91 | 1.86 | 1.81 | 1.79 |
| | In leaf . . | 5.37 | 4.99 | 4.31 | 4.46 | 5.08 |
| Phosphoric acid in dry | In root . . | 0.54 | 0.49 | 0.55 | 0.61 | 0.58 |
| | In leaf . . | 0.81 | 0.71 | 0.75 | 0.76 | 0.77 |
| **PER ACRE, LB.** | | | | | | |
| Dry matter | In root . . | 2259 | 3026 | 2843 | 4138 | 3232 |
| | In leaf . . | 296 | 493 | 385 | 790 | 557 |
| | Leaf + or − root | −1963 | −2533 | −2458 | −3348 | −2675 |
| Nitrogen . | In root . . | 14.5 | 22.6 | 23.2 | 35.7 | 26.4 |
| | In leaf . . | 7.2 | 13.0 | 10.1 | 23.1 | 15.4 |
| | Leaf + or − root | −7.3 | −9.6 | −13.1 | −12.6 | −11.0 |
| Mineral matter | In root . . | 95.8 | 154.6 | 140.5 | 218.8 | 171.0 |
| | In leaf . . | 64.7 | 110.4 | 79.9 | 163.1 | 119.2 |
| | Leaf + or − root | −31.1 | −44.2 | −60.6 | −55.7 | 51.8 |
| Potash . | In root . . | 35.3 | 57.7 | 52.9 | 75.1 | 57.8 |
| | In leaf . . | 15.9 | 24.6 | 16.6 | 35.2 | 28.3 |
| | Leaf + or − root | −19.4 | −33.1 | −36.3 | −39.9 | −29.5 |
| Phosphoric acid | In root . . | 12.3 | 14.9 | 15.7 | 25.2 | 18.9 |
| | In leaf . . | 2.4 | 3.5 | 2.9 | 6.0 | 4.3 |
| | Leaf + or − root | −9.9 | −11.4 | −12.8 | −19.2 | −14.6 |

*Nitrogenous residue.* Referring to the results given in the lower division of the Table (12) relating to the amounts per acre of dry matter, nitrogen and total mineral matter, it is seen that, comparing the other series with Series 1, there is a considerable increase in the amount of dry substance per acre in the root, and some in the leaf also, due to nitrogenous residue. There is, moreover, notable increase in the amount of nitrogen stored up in both the root and the leaf over a given area, due to residue; but much less than there was under the influence of direct supply.

*Nitrogen and mineral matter in the root.* Comparing the average annual amounts of dry substance, of nitrogen, and of mineral matter, per acre, over the two years of the action of residue with those over the three years of direct supply, there is in each of the Series 2, 3, 4, and 5, less than half as much dry matter per acre in the roots over the two as over the three years. There is about or less than half, and even only one-third, as much nitrogen accumulated in the roots over the two years; and there is also generally less than half as much increase of nitrogen in the leaves over the two years. Further, though the supply was the same each year, there was less than half as much total mineral matter in the roots, and generally less than half as much in the leaves, under the influence of the restricted supply of nitrogen and coincident restricted growth. In reference to these points, it is to be borne in mind that the leaves were always returned to the land.

*Exhaustion of soil nitrogen.* Whilst there is in the above facts clear evidence of considerable effect from previously unexhausted nitrogenous manure and crop-residue, there is at the same time in the lower percentage of nitrogen in the roots, and in the much lower amounts per acre, both of dry substance and of nitrogen in the crops growing under the influence of only residual supply, clear indication that the nitrogenous accumulations available within the soil, whether from manure- or from crop-residue, were rapidly becoming exhausted.

*Potash in the root.* The figures relating to the potash per cent in the dry matter of the roots, and per acre in the roots, show (with the continued annual supply of potash), as in the case of the three years, a high percentage in the dry matter with high luxuriance—that is, where there had been a large amount of nitrogenous manure- and crop-residue; and the percentages are with one exception higher over the two years, with the same supply of potash, but much less available nitrogen, and much less luxuriance and total growth, than over the three years with the direct supply of nitrogen. On the other hand, the quantities of potash per acre in the roots, although much larger with nitrogenous residue and increased growth than with the mineral manure alone, are, with the much less

growth than during the three years, generally only about half as much as over the preceding period; but, as above stated, the amount was greater in proportion to the dry substance produced—the supply of potash being the same, but the available nitrogen and the consequent growth much less. Further, as over the three years, so now over the two years with only residual nitrogenous supply, and very much less growth, the percentage of potash in the dry matter of the leaf is very much higher than in that of the root; but also as over the three years, the actual quantity of potash per acre in the leaf is very much less than that in the root.

*Phosphoric acid in the root.*

As to the phosphoric acid, its percentage in the dry substance of the root is fairly uniform throughout the five series with the same supply of it by manure, but with great difference in the available supply of nitrogen and in the amounts of growth. The amounts of phosphoric acid per acre in the roots are, however, by no means uniform in the different series, but have a very obvious relation to the quantities of dry substance grown. The percentage of phosphoric acid in the dry substance of the leaf is also pretty uniform throughout the different series; but the quantities per acre in the leaf, as in the root, have distinct relation to the amounts of growth. They are, however, in all cases much smaller than those in the root, and very much smaller than the amounts of potash in the leaf.

The relation of the potash and phosphoric acid to the amount of substance grown will be further referred to presently.

*Produce of sugar.*

The following Table (13) shows—in the upper division the percentage of sugar in the sugar-beet roots under the specified different conditions of manuring; in the second division the amounts of sugar yielded per acre (in lb.); in the third division the increase of sugar per acre by the nitrogenous manures; and in the bottom division the increased amount of sugar for 1 lb. of nitrogen supplied in manure. The mean results are given for the three years of the direct nitrogenous supply, for the two years of residual supply only, and for the five years, three with, and two without, the direct supply. Further, the results are given both for plot 5 with superphosphate only as the standard or mineral manure, and for the mean of plots 6 and 4, the former with superphosphate and potash, and the latter with superphosphate, potash, soda, and magnesia, as the mineral manure.

*Effect of manures on percentage of sugar.*

It may in the first place be observed that the percentage of sugar is about one and a-half time as high as in mangel-roots grown under similar conditions as to manuring. Referring to the results for the first three years, the table shows that the percentage of sugar is the highest in Series 1—that

TABLE 13.—SUGAR-BEET. Sugar per cent and per acre per annum in the roots. Averages of 3 years, 1871-73; 2 years, 1874-75; and 5 years, 1871-75.

| Period. | Plot. | Standard manures. | Series 1. Standard manures only, every year. | Standard manures, every year, and - Series 2. Sodium nitrate =86 lb. nitrogen (3 years only). | Series 3. Ammonium-salts =86 lb. nitrogen (3 years only). | Series 4. Ammonium-salts and rape-cake =184 lb. nitrogen (3 years only). | Series 5. Rape-cake =98 lb. nitrogen (3 years only). |
|---|---|---|---|---|---|---|---|
| **SUGAR PER CENT.** | | | | | | | |
| 3 years, 1871-73 | 5 | Superphosphate | 13.08 | 10.66 | 11.88 | 9.89 | 12.17 |
| | 4 & 6 | Superphosphate and potash | 12.97 | 11.04 | 12.16 | 10.66 | 12.07 |
| 2 years, 1874-75 | 5 | Superphosphate | 12.31 | 10.36 | 11.61 | 10.78 | 10.72 |
| | 4 & 6 | Superphosphate and potash | 12.05 | 10.60 | 11.99 | 11.17 | 11.22 |
| 5 years, 1871-75 | 5 | Superphosphate | 12.77 | 10.54 | 11.77 | 10.25 | 11.59 |
| | 4 & 6 | Superphosphate and potash | 12.60 | 10.86 | 12.09 | 10.86 | 11.73 |
| **SUGAR PER ACRE, LB.** | | | | | | | |
| 3 years, 1871-73 | 5 | Superphosphate | 1731 | 4661 | 3563 | 3886 | 4407 |
| | 4 & 6 | Superphosphate and potash | 1704 | 4635 | 4063 | 5279 | 4788 |
| 2 years, 1874-75 | 5 | Superphosphate | 1584 | 2053 | 1963 | 2591 | 2065 |
| | 4 & 6 | Superphosphate and potash | 1531 | 2045 | 2047 | 2825 | 2262 |
| 5 years, 1871-75 | 5 | Superphosphate | 1672 | 3618 | 2923 | 3368 | 3470 |
| | 4 & 6 | Superphosphate and potash | 1635 | 3599 | 3257 | 4297 | 3778 |
| **INCREASE OF SUGAR PER ACRE OVER SERIES 1, LB.** | | | | | | | |
| 3 years, 1871-73 | 5 | Superphosphate | ... | 2930 | 1832 | 2155 | 2676 |
| | 4 & 6 | Superphosphate and potash | ... | 2931 | 2359 | 3575 | 3084 |
| 2 years, 1874-75 | 5 | Superphosphate | ... | 469 | 379 | 1007 | 481 |
| | 4 & 6 | Superphosphate and potash | ... | 514 | 516 | 1294 | 731 |
| 5 years, 1871-75 | 5 | Superphosphate | ... | 1946 | 1251 | 1696 | 1798 |
| | 4 & 6 | Superphosphate and potash | ... | 1964 | 1622 | 2662 | 2143 |
| **LB. INCREASE OF SUGAR FOR 1 LB. NITROGEN IN MANURE.** | | | | | | | |
| 3 years, 1871-73 | 5 | Superphosphate | ... | 34.1 | 21.3 | 11.7 | 27.3 |
| | 4 & 6 | Superphosphate and potash | ... | 34.1 | 27.4 | 19.4 | 31.5 |
| 5 years, 1871-75 | 5 | Superphosphate | ... | 37.7 | 24.2 | 15.4 | 30.6 |
| | 4 & 6 | Superphosphate and potash | ... | 38.1 | 31.4 | 24.1 | 36.4 |

is, without nitrogenous supply, with the least luxuriance, and the smallest and ripest roots, the mean for plots 6 and 4 amounting to 12.97 per cent. On the other hand, in Series 4, with the highest nitrogenous manure, the greatest luxuriance, and the least maturity, the percentage is only 10.66. Comparison of the percentages of dry matter and of sugar show that the sugar constituted about or more than two-thirds of the total dry or solid substance of the root. As a rule, where nitrogenous manure was used there was a somewhat higher percentage of sugar with than without potash supply. There was also generally a somewhat higher percentage over the three years of direct nitrogenous supply than over the succeeding two years.

*Manuring and yield of sugar.* Referring to the second division of the table, which shows the amounts of sugar per acre under the different conditions as to manuring, it is seen that over the three years the mean produce of plots 6 and 4 with potash was, without nitrogenous manure 1704 lb.; with nitrate in addition 4635 lb.; with ammonium-salts 4063 lb.; with ammonium-salts and rape-cake 5279 lb.; and with rape-cake 4788 lb. In other words, with little more than three-fourths of a ton of sugar per acre with the mineral manure alone, there was, with nitrogenous manure in addition—when as ammonium-salts more than 1¾ ton, with nitrate more than 2 tons 1 cwt., with rape-cake nearly 2 tons 3 cwt., and with rape-cake and ammonium-salts more than 2 tons 7 cwt., of sugar produced per acre. Over the subsequent two years, without further nitrogenous supply, there was, however, generally about, or not much more than, half as much sugar yielded.

*Superphosphate and potash.* The third division of the table shows that with superphosphate and potash as the mineral manure, there was over the three years an average annual increase of sugar yielded, per acre, due to the nitrogenous supply, of 2931 lb. by the nitrate, of 2359 lb. by the ammonium-salts, of 3575 lb. by the ammonium-salts and rape-cake, and of 3084 lb. by the rape-cake. Over the succeeding two years, however, the increased production of sugar, due to the nitrogenous residue, was, with the nitrate less than one-fifth, with the ammonium-salts rather more than one-fifth, with the ammonium-salts and rape-cake more than one-third, and with the rape-cake alone less than one-fourth, as much as over the three years with the direct supply of nitrogen.

*Dependence on supply of nitrogen.* Upon the whole, therefore, it is evident that even with a full supply of mineral manure the produce of sugar was small, and that the increased production of that non-nitrogenous substance was dependent on the available supply of nitrogen within the soil. Examination of the table will

further show that where ammonium-salts, ammonium-salts and rape-cake, or rape-cake alone, was employed, there was considerably more sugar produced on plots 4 and 6, where potash was supplied, than on plot 5, where superphosphate was the only mineral manure. Doubtless with the continued supply of superphosphate alone as the mineral manure, and the growth forced by nitrogenous supply, the amount of potash available within the range of the roots had become more or less exhausted. Where the nitrogen was applied as nitrate, however, there was no deficiency of sugar-production with superphosphate only as the mineral manure; a result probably due, as already observed, to the greater range of the roots induced under the influence of the soluble and more rapidly distributed nitrate, thus securing a better command of the potash of the soil and subsoil.

*Sugar-production and supply of nitrogen.*

The bottom division of the table illustrates very strikingly the interesting fact of the dependence of the amount of the non-nitrogenous substance—sugar—produced on the amount of nitrogen available within the soil. Thus, taking the results for plots 6 and 4, with full mineral supply including potash, there is over the three years—for 1 lb. of nitrogen supplied—when as nitrate 34.1 lb., as ammonium-salts 27.4 lb., as rape-cake 31.5 lb., and when applied in excessive amount in ammonium-salts and rape-cake together 19.4 lb., of sugar produced. Taking the results for the five years, three with direct supply and two with residue only, the increased production of sugar for 1 lb. of nitrogen supplied is somewhat greater—namely, with the nitrate 38.1 lb., with the ammonium-salts 31.4 lb., with the rape-cake 36.4 lb., and with the ammonium-salts and rape-cake together 24.1 lb. It will be seen, however, that when superphosphate without potash was used as the mineral manure, the produce of sugar for a given amount of nitrogen in manure was, excepting in the case of the nitrate, distinctly less.

*Carbohydrates of plants and supply of nitrogen.*

It is not only in the case of sugar-beet that the amount produced of the special carbohydrate of the plant is largely influenced by the supply of nitrogen. It is so in the case of root-crops generally, which may be fitly called sugar-crops. As we shall see further on, the result is very similar in the case of grain crops, the produce of which is greatly increased by nitrogenous manures; and in their case it is the carbohydrates—starch and cellulose—that are chiefly produced. It is also much the same with potatoes, the increased production of starch being then the characteristic result. In fact it will be found that nitrogenous manures are chiefly used for crops poor in nitrogen, the increased produce of which is characteristically that of non-nitrogenous bodies. Without attempting to give a physiological explanation of

*Nitrogenous manures for crops poor in nitrogen.*

the result, it may at any rate be stated as a matter of fact that nitrogenous manures greatly increase the general vegetative activity of such plants, and consequently, if the other necessary supplies are not wanting, the activity of the formation of their natural or characteristic products is enhanced.

*Potash and yield of sugar.*

It has been seen that the supply of potash as well as of nitrogen has much to do with the amount of root-development, and the amount of sugar produced. The following table shows the amounts of sugar for 1 of potash, in the roots. The supply of potash was the same in all cases; in Series 1 without any nitrogenous manure, but in the other series the nitrogenous manures as indicated, in each of the first three years. The results are the means of plots 6 and 4, over the three years with the direct supply of nitrogen, over the two years without further nitrogenous supply, and over the five years, three with and two without, nitrogenous manure on Series 2, 3, 4, and 5.

SUGAR FOR 1 OF POTASH IN THE ROOTS.

| | Series 1. Without nitrogenous manure. | Series 2. With sodium nitrate | Series 3. With ammonium-salts. | Series 4. With rape-cake and ammonium-salts. | Series 5. With rape-cake. |
|---|---|---|---|---|---|
| 3 years, 1871-73 . . | 47.9 | 39.6 | 38.9 | 34.1 | 42.0 |
| 2 years, 1874-75 . . | 43.4 | 35.5 | 38.7 | 37.6 | 39.1 |
| 5 years, 1871-75 . . | 46.1 | 38.6 | 38.9 | 34.9 | 41.3 |

In the first place, it is to be observed that the amount of sugar for 1 of potash in the roots is considerably the greater where no nitrogen was supplied by manure, and where there was no luxuriance, and by far the ripest roots; conditions under which the sugar produced would presumably be the maximum for the amount of nitrogen available, and probably also the maximum for the amount of potash present in the roots. On the other hand, the lowest amounts of sugar for 1 of potash are, upon the whole, in Series 4, where there was excess of nitrogen, great luxuriance, the lowest maturation, and consequently the crudest juice. Comparing period with period, the least amount of sugar for 1 of potash in the roots was generally over the two years with full supply of potash, but deficient supply of nitrogen, and deficient yield of sugar. In the cases of most normal growth, it would seem that there were for 1 part of potash about, or nearly, 40 parts of sugar in the roots. In reference to these results, it is to be borne in mind that the percentage of potash remaining in the dry substance of the leaf, where

carbohydrates are so largely formed, was much higher than in that of the root; though, as Tables 10 and 12 show, by far the greater part of the total potash of the crop was found in the root, where is the great accumulation of sugar.

*Nitrogen supplied in manure and regained in crop.*

Before leaving the subject of the experiments with sugar-beet, it will be well to refer briefly to the amount of the nitrogen supplied in manure which is recovered in the increase of crop. Below are shown the amounts recovered in the increased produce of the roots only, taking the mean of plots 6 and 4, with potash as well as superphosphate as the mineral manure. The results are given for the three years of the direct supply of the nitrogenous manures, and for five years, three with and two without, the direct supply; and the figures show the amounts of nitrogen recovered in the increased produce of roots for 100 supplied in manure:—

| | 3 Years. | 5 Years. |
|---|---|---|
| With nitrate of soda . . . | 61.3 | 66.9 |
| With ammonium-salts . . | 42.9 | 49.0 |
| With rape-cake . . . | 45.0 | 52.7 |
| With rape-cake and ammonium-salts. | 49.6 | 57.4 |

As the leaves are annually returned to the land as manure, it will be obvious that, taking the average over a number of years, it is only the amount in the roots that can be credited as immediate return from the manure employed. It is seen that the highest amount recovered is from nitrate of soda—namely, 61.3 per cent over the 3 years, and 66.9 per cent over the 5 years; next we have 49.6 per cent over the 3 years, and 57.4 per cent over the 5 years, with ammonium-salts and rape-cake; then 45 per cent over the 3 years, and 52.7 per cent over the 5 years, with rape-cake; and lastly, only 42.9 per cent over the 3 years, and only 49.0 per cent over the 5 years, with ammonium-salts. These amounts are, however, higher than those obtained with wheat or barley—a result no doubt chiefly due to the period of accumulation and growth extending much later in the season than in the case of those grain crops; and hence also, no doubt, is to be explained the much greater accumulation of nitrogen under equal conditions of soil by maize than by either wheat or barley. We shall recur to this subject further on.

### 4. *Experiments with Mangel-Wurzel.*

*Plan of experiments with mangel-wurzel.*

We have now to consider the results of experiments with manzel-wurzel, a variety of beet largely used in some districts of our own country for feeding purposes. The experiments were made in the same field, and on the same plots as those

with the turnips and sugar-beet; and following the sugar-beet, they were commenced in 1876, and are still continued—the last crop, that of 1894, being therefore the nineteenth in succession. We propose to draw our illustrations from results obtained in the field during the 17 years, 1876-92, and in the laboratory during shorter periods.

Table 14 (p. 50) gives the average produce—roots, leaves, and total—over the 17 years for six plots, each with five different conditions as to nitrogenous supply.

*Mangels and turnips compared.*

A glance at the table shows that the produce of roots of the mangel-wurzel is on a much higher level than that of either common or Swedish turnips, and there is also much more leaf. There was, however, a general similarity in amount of produce obtained under similar conditions of manuring with the mangel as with the sugar-beet. Compared with turnips, the mangel-seed is sown earlier, and the plant has a longer period of growth. It has a much more deeply penetrating tap-root, throws out a less proportion of its feeding-roots near the surface, and exposes a comparatively large area of leaf to the atmosphere. With its more extended root-range, it is less dependent on continuity of rain when growth is once well established; and it bears, or rather requires, for full growth a higher temperature than the turnip. These conditions determine in what localities it is most suitably grown in this country. But where the soil and climate are suitable, very much larger crops can be obtained than of turnips. The mangel requires, however, very heavy dressings of manure if it is to yield full crops.

*Dung and superphosphate.*

The Table (14) shows that with farmyard manure alone, which was applied at the rate of 14 tons per acre per annum, there was an average produce of 15½ tons of roots, and that the addition of superphosphate of lime increased it very little. This result, compared with that with turnips, is quite consistent with the difference in the character and range of the feeding-roots of the two crops; and it is also quite consistent with common experience in the matter.

*Nitrogenous manures.*

Notwithstanding that the amount of farmyard manure employed would supply annually about 200 lb. of nitrogen per acre per annum, it is seen that the addition of specially nitrogenous manures greatly increased the crops. Thus the average produce was raised from 15 tons 10 cwt. to 21 tons 8 cwt. by the addition of nitrate of soda, to 21 tons 1 cwt. by ammonium-salts, to 22 tons 18 cwt. by rape-cake, and to 23 tons 16 cwt. by ammonium-salts and rape-cake together.

*Mineral manure alone and with nitrogenous manures.*

With purely mineral manure the produce of this more powerfully rooting plant is much higher than was obtained with Swedish turnips by the same manures. The addition

TABLE 14.—MANGEL-WURZEL. Average produce of 17 seasons, 1876-92. Quantities per acre per annum.

| Plot. | Standard manures. | Series 1 Standard manures only | | Standard manures, and— Series 2 Sodium nitrate =86 lb nitrogen | | Series 3 Ammonium salts =86 lb nitrogen. | | Series 4 Ammonium salts and rape-cake = 184 lb nitrogen. | | Series 5 Rape-cake =98 lb nitrogen | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **ROOTS** | | | | | | | | | | |
| | | tons. | cwt | tons. | cwt | tons. | cwt | tons | cwt | tons | cwt |
| 1 | Farmyard manure | 15 | 10 | 21 | 8 | 21 | 1 | 23 | 16 | 22 | 18 |
| 2 | Farmyard manure and superphosphate | 15 | 15 | 22 | 8 | 20 | 6 | 22 | 16 | 22 | 10 |
| 3 | No mineral manure | 4 | 4 | 12 | 11 | 6 | 6 | 10 | 1 | 10 | 12 |
| 5 | Superphosphate | 4 | 15 | 14 | 14 | 8 | 1 | 10 | 17 | 11 | 12 |
| 6 | Superphosphate and potassium sulphate | 4 | 5 | 14 | 16 | 13 | 9 | 21 | 3 | 17 | 2 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 5 | 2 | 17 | 6 | 14 | 13 | 24 | 6 | 19 | 16 |
| | Mean of 6 and 4 | 4 | 14 | 16 | 1 | 14 | 1 | 22 | 15 | 18 | 9 |
| | **LEAVES** | | | | | | | | | | |
| 1 | Farmyard manure | 2 | 15 | 4 | 1 | 5 | 2 | 5 | 17 | 4 | 4 |
| 2 | Farmyard manure and superphosphate | 2 | 14 | 4 | 9 | 5 | 0 | 5 | 17 | 4 | 3 |
| 3 | No mineral manure | 0 | 19 | 3 | 1 | 2 | 14 | 3 | 18 | 2 | 18 |
| 5 | Superphosphate | 1 | 0 | 3 | 1 | 2 | 18 | 3 | 19 | 3 | 1 |
| 6 | Superphosphate and potassium sulphate | 0 | 18 | 2 | 15 | 2 | 14 | 5 | 3 | 2 | 18 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 1 | 1 | 3 | 11 | 2 | 14 | 5 | 3 | 3 | 6 |
| | Mean of 6 and 4 | 0 | 19 | 3 | 3 | 2 | 14 | 5 | 3 | 3 | 2 |
| | **TOTAL PRODUCE (ROOTS AND LEAVES)** | | | | | | | | | | |
| 1 | Farmyard manure | 18 | 5 | 25 | 9 | 26 | 3 | 29 | 13 | 27 | 2 |
| 2 | Farmyard manure and superphosphate | 18 | 9 | 26 | 17 | 25 | 6 | 28 | 13 | 26 | 13 |
| 3 | No mineral manure | 5 | 3 | 15 | 12 | 9 | 0 | 13 | 19 | 13 | 10 |
| 5 | Superphosphate | 5 | 15 | 17 | 15 | 10 | 19 | 14 | 16 | 14 | 13 |
| 6 | Superphosphate and potassium sulphate | 5 | 3 | 17 | 11 | 16 | 3 | 26 | 6 | 20 | 0 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 6 | 3 | 20 | 17 | 17 | 7 | 29 | 9 | 23 | 2 |
| | Mean of 6 and 4 | 5 | 13 | 19 | 4 | 16 | 15 | 27 | 18 | 21 | 11 |

of nitrogenous manures in some cases more than quadrupled the produce. Thus the average produce of plots 6 and 4, with potash as well as superphosphate as the mineral manure, was, with the mineral manure alone 4 tons 14 cwt., with the addition of nitrate 16 tons 1 cwt., with that of ammonium-salts 14 tons 1 cwt., with rape-cake 18 tons 9 cwt., and with ammonium-salts and rape-cake together 22 tons 15 cwt.

*Potash.* With the comparatively limited growth of turnips potash manures had little effect; but here, after years of further exhaustion of the potash within the soil, and with so much more vegetable matter produced, the deficiency of potash where it had not been applied is very obvious. Thus with ammonium-salts and superphosphate the average produce was only 8 tons 1 cwt.; but taking the mean of plots 6 and 4 with the ammonium-salts, superphosphate, and potash also, the average produce was 14 tons 1 cwt. Again, with superphosphate and rape-cake, the average produce was only 11 tons 12 cwt., but that of plots 6 and 4 with potash in addition was 18 tons 9 cwt. Lastly, with ammonium-salts, rape-cake, and superphosphate, the average produce was only 10 tons 17 cwt., but that of plots 6 and 4 with potash in addition was 22 tons 15 cwt., or more than twice as much.

*Effect of season.* In reference to the average results over the 17 years shown in the table, it may be stated that in favourable seasons very much larger crops were obtained. Indeed in several seasons more than 30 tons of roots have been obtained by farmyard manure and artificial nitrogenous supply in addition; whilst in one case with the full mineral manure, including potash and the highest nitrogenous supply, more than 37 tons was obtained.

*Manures and leaf-production.* The proportion of leaf to root will be considered further on; but the table shows that the actual amount of leaf was very much increased by the nitrogenous manures, and that with farmyard manure and the highest artificial nitrogenous supply, there was an average of nearly 6 tons of leaf.

*Large yields.* The lower division of the table shows in several cases an average total produce, root and leaf together, of nearly 30 tons, and in some years there has been more than 40 tons. The very great power of utilising manure and of producing vegetable substance possessed by the mangel is thus strikingly illustrated.

*Do roots draw nitrogen from the air?* It has sometimes been assumed, however, that by virtue of the large amount of leaf-surface which root-crops expose to the atmosphere, they obtain a large amount of their nitrogen from that source. It is further assumed that if a small quantity of nitrogenous manure be applied so as to favour the early development of the plant, it will then obtain the

*Table 15 explained.* remainder from the atmosphere. The results given in Table 15 afford pretty conclusive evidence against such a view. There is there given the average produce of mangel-wurzel —root, leaf, and total crop—over five years:—

1. By superphosphate of lime and potassium sulphate.
2. By the same mineral manures with, in addition, ammonium-salts, supplying 7.8 lb. nitrogen per acre per annum.
3. The same mineral manures and ammonium-salts, supplying 86 lb. nitrogen per acre per annum.

TABLE 15.—Mangel-Wurzel. Average produce, 5 years, 1876-80. Quantities per acre per annum.

| | | Roots. | | Leaves | | Total. | |
|---|---|---|---|---|---|---|---|
| | | tons. | cwt | tons. | cwt | tons. | cwt |
| 1 | Superphosphate of lime and potassium sulphate | 4 | 10 | 1 | 0 | 5 | 10 |
| 2 | As 1, and 36½ lb. ammonium-salts (=7.8 lb. nitrogen) | 6 | 0 | 1 | 6 | 7 | 6 |
| 3 | As 1, and 400 lb. ammonium-salts (=86 lb. nitrogen) | 14 | 0 | 2 | 16 | 16 | 16 |

*Effect of large and small supplies of nitrogen.* Thus the annual application of 7.8 lb. of nitrogen increased the crop by only 30 cwt. of roots per acre per annum; and it may be mentioned that the increased yield of nitrogen in the crop was even less than that supplied in the manure. The application of 86 lb. of nitrogen, however, further increased the crop of roots by 160 cwt. more, or by 190 cwt. in all. It is obvious that the application of the small amount of nitrogen (7.8 lb.) did not enable the plant to take up any from the atmosphere, and that it required a further supply by manure to obtain a further increase of crop.

*Soil the source of nitrogen for roots and cereals.* It cannot be doubted that beyond the small amount of combined nitrogen which annually comes down from the atmosphere in rain and the minor aqueous deposits, the source of the large amount of nitrogen of root-crops is the store of it within the soil, whether this be due to less recent accumulations or to direct supply by manure. Further confirmation of the conclusion that the source of the nitrogen of root-crops, as of cereals and others, is the supplies within the soil, is to be found in the fact that after many years of the growth of such crops by mineral manures without nitrogen, the surface-soil showed a lower percentage of nitrogen than has been found in any of the other experimental fields. It is indeed certain that if root-crops are to yield large

amounts of produce, they must find within the soil a large supply of available nitrogen. On the other hand, the large amounts of produce obtained by the aid of nitrogenous manures, on plots to which no carbonaceous manure has been applied for about 50 years, is evidence that the atmosphere is at any rate the chief, if not the exclusive, source of the carbon of the crops.

*Table 16 explained.*

The next Table (16) shows the proportion of leaf to root, and the amount and distribution of certain constituents in the root and in the leaf respectively. The results relate to the mean produce of plots 6 and 4, with potash as well as superphosphate as the mineral manure; and they are given for each of the five series—that is, with the mineral manure alone, and with the various nitrogenous manures in addition. Further, the results are the averages for six years, 1878-83.

*Proportions of root and leaf.*

The first line of figures shows that the proportion of leaf to 1000 root ranged from 152 to 216, and that it was the highest with the highest manure, and the greatest luxuriance. The proportion of leaf was considerably higher than in the case of Swedish turnips, but very much lower than with common turnips. With the same description of roots there will, however, generally be the higher proportion of leaf the heavier the soil, the wetter the season, the higher the nitrogenous manuring, and the less ripe the crop.

*Composition of root and leaf as influenced by manures.*

Referring to the percentage composition of the mangel root and leaf, it is to be observed that whilst with turnips there was a much higher percentage of dry substance in the leaf than in the root, there is in the mangels, as there was in the sugar-beet, a considerably higher percentage in the root than in the leaf. The percentage of dry substance in the mangel root is in fact considerably higher than in the Swedish turnip root, whilst the percentage in the mangel leaf is much lower than in the turnip leaf. The question suggests itself, To what extent this may be due to more complete exhaustion of the leaf in the accumulation of the larger amount of reserve material, chiefly sugar, in the root?

The percentage of nitrogen in the dry substance of the root is much the higher the higher the nitrogenous manuring; indeed it is with the highest supply of nitrogen $1\frac{3}{4}$ time as high as with the mineral manure alone. It will be seen further on, however, that beyond comparatively narrow limits a high percentage of nitrogen may even be a disadvantage, so far as the feeding quality of the root is concerned. As in the case of the turnips, the percentage of nitrogen in the dry substance of the leaf is very much higher than in that of the root, and it is the higher in the leaf the less matured the root.

TABLE 16.—MANGEL-WURZEL. Results for 6 years, 1878-83. Means of plots 6 and 4.

| | | Series 1. Mineral manure alone. | Series 2. Mineral and sodium nitrate =86 lb. nitrogen. | Series 3. Mineral and ammonium-salts =86 lb. nitrogen. | Series 4. Mineral and ammonium-salts and rape-cake =184 lb. nitrogen. | Series 5. Mineral and rape-cake =98 lb. nitrogen. |
|---|---|---|---|---|---|---|
| LEAF TO 1000 ROOT. | | | | | | |
| | | 197 | 178 | 177 | 216 | 152 |
| PER CENT. | | | | | | |
| Dry matter | In root | 14.98 | 12.70 | 13.58 | 12.60 | 13.20 |
| | In leaf | 10.61 | 9.58 | 9.71 | 9.53 | 10.28 |
| Nitrogen in dry | In root | 0.88 | 1.34 | 1.13 | 1.55 | 1.20 |
| | In leaf[1] | 2.55 | 2.94 | 2.86 | 3.29 | 2.88 |
| Mineral matter in dry | In root | 5.72 | 7.31 | 6.80 | 7.63 | 6.88 |
| | In leaf | 20.61 | 20.19 | 20.72 | 20.62 | 20.08 |
| Potash in dry | In root[2] | 2.70 | 2.40 | 3.15 | 3.23 | 2.98 |
| | In leaf[2] | 5.15 | 1.92 | 4.08 | 3.48 | 3.99 |
| Phosphoric acid in dry | In root[2] | 0.66 | 0.62 | 0.60 | 0.58 | 0.63 |
| | In leaf[2] | 0.69 | 0.65 | 0.65 | 0.60 | 0.61 |
| PER ACRE, LB. | | | | | | |
| Dry matter | In root | 1502 | 4877 | 4443 | 6533 | 5188 |
| | In leaf | 210 | 653 | 565 | 1062 | 610 |
| | Leaf + or − root | −1292 | −4224 | −3878 | −5471 | −4578 |
| Nitrogen | In root | 12.9 | 64.4 | 49.2 | 97.4 | 61.2 |
| | In leaf[3] | 5.4 | 19.2 | 16.2 | 34.9 | 17.6 |
| | Leaf + or − root | −7.5 | −45.2 | −33.0 | −62.5 | −43.6 |
| Mineral matter | In root | 84.4 | 350.6 | 296.9 | 481.4 | 348.4 |
| | In leaf | 42.2 | 131.7 | 117.0 | 217.6 | 121.3 |
| | Leaf + or − root | −42.2 | −218.9 | −179.9 | −263.8 | −227.1 |
| Potash | In root[4] | 40.9 | 125.3 | 142.0 | 225.0 | 164.6 |
| | In leaf[4] | 10.8 | 13.0 | 23.8 | 38.2 | 25.0 |
| | Leaf + or − root | −30.1 | −112.3 | −118.2 | −186.8 | −139.6 |
| Phosphoric acid | In root[4] | 10.0 | 32.6 | 26.9 | 40.4 | 35.0 |
| | In leaf[4] | 1.4 | 4.4 | 3.8 | 6.6 | 3.8 |
| | Leaf + or − root | −8.6 | −28.2 | −23.1 | −33.8 | −31.2 |

[1] Determinations made on mixed samples of plots 4, 5, and 6.
[2] These results relate to plot 6 only.
[3] Calculated from the determinations made on mixed samples of plots 4, 5, and 6.
[4] Calculated from the percentage results relating to plot 6 only.

The percentage of total mineral matter is on the average about three times as high in the dry substance of the leaf as in that of the root. It is, however, higher in the dry substance of the root, and lower in that of the leaf, than in the case of the sugar-beet. Further, the table shows that, excepting in the case of Series 2 with nitrate of soda, and much soda in the ash, there was a higher percentage of potash in the dry substance of the leaf than in that of the root; but about the same percentage of phosphoric acid in the dry substance of the leaf as in that of the root. It is to be observed, however, that the percentage of potash in the dry matter of the mangel root is much higher than in that of the sugar-beet root, in which so much more sugar, and with it so much more dry substance, is produced. On the other hand, the percentage of potash in the dry substance of the mangel leaf is generally distinctly lower than in the case of the sugar-beet.

*Ripeness and composition of root and leaf.*

Upon the whole, the percentage results show the higher percentage of dry matter and the lower percentage of nitrogen in the dry matter in both root and leaf the riper the crop; also the lower percentage of total mineral matter in the dry substance of the root the riper the crop; and conversely, there is a lower percentage of dry matter and a higher percentage of both nitrogen and mineral matter in the dry substance the more luxuriant and less ripe the crop.

The lower division of the Table (16) shows that whilst there was only about two-thirds of a ton of dry substance per acre in the root (that is, in the food-product of the crop) without nitrogenous manure, there were nearly 3 tons with the highest nitrogenous manure; and there was, besides, about five times as much dry substance per acre in the leaf of the larger as in that of the smaller crop. There is here, again, a striking illustration of the dependence of the amount of carbon assimilated from the atmosphere over a given area on the amount of nitrogen available to the plant within the soil. The quantity of dry substance produced per acre under the influence of the highest nitrogenous manuring would contain considerably more than 1 ton of carbon; indeed the increased amount of carbon assimilated under the influence of the nitrogenous manuring would be not much less than 1 ton per acre.

The table further shows that with the highest nitrogenous manuring, the greatest luxuriance, and the lowest maturation of the crop, there was more than six times as much solid matter accumulated in the food-product, the root, as in the leaf; whilst in the other cases, with smaller crops and better maturation, there was from seven to eight times as much

solid matter in the root as in the leaf. Again, notwithstanding the much higher percentage of nitrogen in the dry substance of the leaf than in that of the root, there was, owing to the small proportion of leaf, generally less than one-third as much nitrogen remaining in the leaf (only for manure again) as was accumulated in the edible root. Of total mineral matter there was also much less remaining in the leaf than was stored up in the root. Lastly, there was very much less of the potash of the crop, and very much less of the phosphoric acid also, in the leaf than in the root.

*Nitrogen supplied and recovered in crop.*

The next point to consider is, What proportion of the nitrogen of the manure, which is seen to be so effective, is recovered in the increase of the crop? Table 17 shows in the column headings the amounts of nitrogen supplied per acre per annum by manure in the case of each of the Series 2, 3, 4, and 5; and below are given the amounts of nitrogen recovered in the increased produce of roots (the leaves being returned to the land) for 100 supplied in manure. Results are given for plot 5 with superphosphate alone as the mineral manure; for plot 6 with superphosphate and potash; and for plot 4 with superphosphate, potash, soda, and magnesia, as the mineral manure. The results are the averages for six years, 1878-83. They are calculated by deducting the amounts of nitrogen in the crops grown by the mineral manure alone from those obtained where nitrogenous manures were used in addition, the difference showing the increased amount of nitrogen in the crop due to nitrogenous supply; and the figures show the increased amount of nitrogen in the roots for 100 supplied in the manure.

TABLE 17.—MANGEL-WURZEL. Nitrogen recovered in increase of roots for 100 in manure. Average for 6 years, 1878-83.

| Plot. | Standard manures. | Standard manures, and— | | | |
|---|---|---|---|---|---|
| | | Series 2. Sodium nitrate =86 lb. nitrogen. | Series 3. Ammonium-salts =86 lb. nitrogen. | Series 4. Ammonium-salts and rape-cake =184 lb. nitrogen. | Series 5. Rape-cake =98 lb. nitrogen. |
| 5 | Superphosphate . . | 57.7 | 29.7 | 25.1 | 38.5 |
| 6 | Superphosphate and potassium sulphate . | 58.1 | 44.5 | 45.5 | 51.8 |
| 4 | Superphosphate, potash, and magnesium sulphates, and sodium chloride . . | 61.7 | 40.1 | 46.4 | 46.8 |
| | Means of plots 6 and 4 | 59.9 | 42.3 | 45.9 | 49.3 |

It should be stated that on the plots of Series 1 with the mineral manures alone, there was obtained in the mangel-roots an average of only about 13 lb. of nitrogen per acre per annum. But it is to be remembered that the plots yielding these very small amounts, even in the powerfully-rooted mangel, had been under experiment with roots for nearly 40 years, during which time they had not received any nitrogen by manure. During the earlier years, however, the common and Swedish turnips yielded much more; but in recent years neither sugar-beet nor mangel-wurzel, even with their greater powers of collection and growth than turnips, has removed so much nitrogen without nitrogenous manure as wheat or barley grown for more than 30 years in succession without artificial nitrogenous supply.

*Influence of mineral manures on the recovery of nitrogen in roots.*

In the first place, the figures show that under each of the conditions of nitrogenous manuring there was more, and with the ammonium-salts or rape-cake very much more, of the supplied nitrogen recovered in the roots where potash as well as superphosphate was used than where superphosphate alone was employed as the mineral manure.

Comparing the average results of the two plots (6 and 4), where both potash and superphosphate were supplied, it is seen that the amounts of nitrogen recovered as increase in the roots for 100 supplied in manure were—

| | |
|---|---|
| With nitrate of soda | 59.9 |
| With ammonium-salts | 42.3 |
| With rape-cake | 49.3 |
| With rape-cake and ammonium-salts | 45.9 |

*50 or 60 per cent of nitrogen supplied in manure not recovered in crop.*

Thus, even under the most favourable conditions as to mineral supply, in three out of the four cases less than 50 per cent of the nitrogen supplied by manure was recovered in the increased produce of roots obtained by its use; and even with the most effective of the nitrogenous manures, the nitrate of soda, scarcely 60 per cent was so recovered. It is true that the nitrogen in the roots alone by no means represents the total quantity assimilated per acre, but as the leaves are annually returned to the land as manure, it is clear that, taking the average over a number of years, it is only the amount in the roots that can be credited as immediate return from the manure employed. Where, however, large amounts of organic matter are returned to the soil, more or less of the at first unrecovered constituents of the manure will remain for future crops.

*Rape-cake and nitrate of soda.*

Then as to the less return in the roots from a given amount of nitrogen supplied as rape-cake than as nitrate of soda, it should be borne in mind that although the nitrogen of such

organic manures only becomes comparatively slowly available, yet on that account the more remains in the soil as manure-residue for future crops.

*Nitrogen supplied in dung.*

Finally, the question obviously suggests itself, What is the result when, instead of these artificial manures, a large amount of nitrogen is supplied in farmyard manure, which must always be liberally employed if heavy crops of mangel-wurzel are to be grown?

In the first place, larger quantities of nitrogen would generally be applied per acre in farmyard manure than in any of the artificial manures used; and the results obtained on the farmyard-manure plots point to the conclusion that a much smaller proportion of that supplied would be taken up by the immediate crop than in the case of either nitrate of soda or ammonium-salts, and even less than with rape-cake. But a characteristic of farmyard manure is that it leaves a large but only slowly available residue within the soil. It is the nitrogen of the liquid dejections of the animals that is first rendered available within the soil, then that of the finely comminuted matter which passes, intermixed with some secretions, in the solid excrements, and finally that in the litter. It is in fact to the very large proportion of the constituents of the farmyard manure applied for root-crops which remains available for future crops that an important part of the benefit of the growth of such crops in rotation is to be attributed. Indeed it will be clearly seen from the evidence adduced that the *root-crops*, which are assumed to perform the office of restoring the condition of the soil for the growth of the crops alternated with them, are themselves pre-eminently dependent on manure for their successful development.

*Root-crops pre-eminently dependent on manure.*

*Value of root-crops in rotation.*

It is in fact the great power of utilising the stores within the soil, due in some cases to accumulation, and in others to direct manuring, which these plants possess, growing and gathering nitrogen as they do after the period of its collection by the cereals, and the fact that it is only a very small proportion of their nitrogen and of their mineral matter which is carried off in the increase of the animals and so lost to the land, that constitute a great part of the value of the root-crops in rotation. When, however, roots are consumed for the production of milk, the loss to the manure will be greater than when they are consumed by either store or fattening animals.

*Production of sugar in mangel crop.*

It is a characteristic of the various descriptions of feeding-roots, that they supply a large amount of the non-nitrogenous, respiratory, and fat-forming substance—sugar; indeed about two-thirds of the solid matter of the mangel-root is sugar.

It will be of interest, therefore, to consider, as in the case of the sugar-beet, both the percentage and the amounts of sugar produced per acre in the mangel under the different conditions of manuring. Table 18 (p. 60) gives particulars on these points. Average results for four years are given, and in each case for five selected plots, with different conditions of mineral and nitrogenous supply.

*Sugar in mangels and nitrogenous manures.*

It is seen that the percentage of sugar is higher in the roots grown by farmyard manure alone than in those with nitrogenous manures in addition. It is higher still when mineral manures are used alone, but here, again, it is reduced by the addition of nitrogenous manures. The fact is that the lower the nitrogenous manuring the riper is the crop, and with this there is the higher percentage of sugar; and conversely, the higher the nitrogenous manuring the more luxuriant the growth, the less ripe the crop, and the lower the percentage of sugar.

Turning to the middle division of the table, it will be seen that notwithstanding the lower percentage of sugar with high nitrogenous supply, the quantity of sugar produced per acre is greatly increased by such supply. Thus, referring to the results with farmyard manure, which is used so largely for the growth of the feeding-beet or mangel, it is seen that, taking the average of four years, the annual produce of sugar was—with the farmyard manure alone 2358 lb., with the addition of nitrate of soda 2916 lb., of ammonium-salts 3409 lb., of rape-cake 3218 lb., and of ammonium-salts and rape-cake 3445 lb. That is to say, the produce by farmyard manure alone was rather more than 1 ton of sugar per acre, which was raised in 2 out of the 4 series by about half a ton by the addition of nitrogenous manure.

*Sugar and mineral manure.*

Referring now to the effects of mineral manure without and with nitrogenous supply, and taking the average of the two plots 6 and 4, with full potash supply as well as superphosphate, it is seen that the mineral manure alone gives 957 lb., or less than half a ton of sugar per acre; and that with nitrogenous manures in addition the quantity is raised to 2740 lb. by the nitrate, to 2487 lb. by the ammonium-salts, to 2873 lb. by the rape-cake, and to 3312 lb. by the ammonium-salts and the rape-cake together—that is, the produce of sugar was raised to 2½ and even to 3½ times as much by the addition of nitrogenous manure. In other words, as shown in the third division of the table, the increased produce of sugar by nitrogenous manure was 1783 lb. by the nitrate, 1530 lb. by the ammonium-salts, 1916 lb. by the rape-cake, and 2355 lb., or more than a ton, by the ammonium-salts and rape-cake together. Comparing these

TABLE 18.—MANGEL-WURZEL. Sugar per cent and per acre per annum in the roots. Average of 4 years, 1877-80.

| Plot. | Standard manures. | Series 1. Standard manures only. | Standard manures, and— Series 2. Sodium nitrate =86 lb. nitrogen. | Series 3. Ammonium-salts =86 lb. nitrogen. | Series 4. Ammonium-salts and rape-cake= 184 lb. nitrogen. | Series 5. Rape-cake; =98 lb. nitrogen. |
|---|---|---|---|---|---|---|
| | **SUGAR PER CENT IN THE ROOTS.** | | | | | |
| | | per cent. | per cent. | per cent. | per cent. | per cent. |
| 1 | Farmyard manure . . | 8.04 | 6.69 | 7.20 | 6.66 | 7.28 |
| 2 | Farmyard manure and superphosphate | 8.10 | 6.42 | 6.80 | 6.63 | 7.27 |
| 5 | Superphosphate . . | 9.74 | 7.07 | 8.68 | 7.45 | 8.82 |
| 6 | Superphosphate and potassium sulphate | 9.61 | 7.39 | 8.36 | 7.45 | 8.28 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 9.43 | 6.97 | 8.00 | 6.63 | 7.51 |
| | Mean of 6 and 4 . | 9.52 | 7.18 | 8.18 | 7.04 | 7.91 |
| | **SUGAR PER ACRE, LB.** | | | | | |
| | | lb. | lb. | lb. | lb. | lb. |
| 1 | Farmyard manure . . | 2358 | 2916 | 3409 | 3445 | 3218 |
| 2 | Farmyard manure and superphosphate | 2487 | 3069 | 3179 | 3148 | 3215 |
| 5 | Superphosphate . . | 965 | 2436 | 1696 | 1888 | 2166 |
| 6 | Superphosphate and potassium sulphate | 847 | 2693 | 2407 | 3294 | 2835 |
| | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 1066 | 2786 | 2567 | 3329 | 2910 |
| | Mean of 6 and 4 . | 957 | 2740 | 2487 | 3312 | 2873 |
| | **INCREASE OF SUGAR PER ACRE OVER SERIES 1.** | | | | | |
| 1 | Farmyard manure . . | ... | 558 | 1051 | 1087 | 860 |
| 2 | Farmyard manure and superphosphate | ... | 582 | 692 | 661 | 728 |
| 5 | Superphosphate . . | ... | 1471 | 731 | 923 | 1201 |
| 6 | Superphosphate and potassium sulphate | ... | 1846 | 1560 | 2447 | 1988 |
| 4 | Superphosphate, potassium, and magnesium sulphates, and sodium chloride | ... | 1720 | 1501 | 2263 | 1844 |
| | Mean of 6 and 4 . | ... | 1783 | 1530 | 2355 | 1916 |
| | **LB. INCREASE OF SUGAR FOR 1 LB. NITROGEN IN MANURE.** | | | | | |
| 5 | Superphosphate . . | ... | 17.1 | 8.5 | 5.0 | 12.3 |
| 6 & 4 | Superphosphate and potassium, &c. | ... | 20.7 | 17.8 | 12.8 | 19.6 |

results with those on plot 5, with superphosphate without potash as the mineral manure, the evidence of the effects of potash on sugar-production is very marked; for the increase is very much less under all the conditions of nitrogenous manuring, but especially with the ammonium-salts, where the superphosphate was used without potash.

This is further strikingly illustrated in the bottom division of the table, which shows the increase of sugar produced for 1 lb. of nitrogen supplied in manure. Thus with full supply of potash the increased production of sugar for 1 lb. of nitrogen was—with the nitrate 20.7 lb., with the ammonium-salts 17.8 lb., with the rape-cake 19.6 lb., and with the excess of nitrogen in the ammonium-salts and rape-cake together only 12.8 lb.; but with the superphosphate without potash the increase was only 17.1 lb. with the nitrate, 8.5 lb. with the ammonium-salts, 12.3 lb. with the rape-cake, and only 5.0 lb. with the excessive amount of nitrogen in the ammonium-salts and rape-cake together.

*Sugar and potash manure.*

Although it is clear, therefore, that the effect on sugar-production of a given amount of nitrogen depended very materially on a liberal supply of potash, the results in the following table (p. 62) show that the amount of sugar for 1 of potash in the roots may vary very greatly according as there is a deficiency or an excessive supply of potash. Thus in the top line of the table we have the amounts of sugar produced for 1 of potash in the roots with superphosphate of lime alone—that is, when there was obviously a deficient supply of potash for full sugar-production under the influence of the amount of nitrogen available. Under these conditions it is to be supposed that there would be the maximum production of sugar for a given amount of potash present. The bottom line shows, on the other hand, the amounts of sugar produced for 1 of potash in the roots where potash was liberally supplied, when doubtless an excess was taken up; and under these conditions it is seen that the amount of sugar produced for 1 of potash in the roots was in all cases of nitrogenous supply and luxuriant growth less than half as much as when there was a deficiency of potash. Comparing these results with mangels, with those relating to sugar-beet as given on p. 47, it is seen that in the case of that crop, where the same amount of potash was supplied, it would, with the much greater amount of sugar produced, not be so much in excess; the amounts of sugar for 1 of potash in the roots being much greater under the corresponding conditions than with the mangels.

*Summary of results.*

To summarise in regard to the mangel-wurzel results on these various points: There is the more sugar produced

the larger the amount of nitrogen supplied, but by no means in proportion to the amount supplied. The efficiency of a given amount of nitrogen is greatly dependent on the completeness of the accompanying mineral supply, and especially on that of potash. Again, the greater the excess of nitrogen, the greater the luxuriance, and the less ripe the roots, the less is the amount of sugar obtained for a given amount of nitrogen supplied. Lastly, it will be remembered that with sugar-beet much more sugar was obtained for a given amount of nitrogen in manure than the above figures show was the case with the mangel-wurzel.

SUGAR FOR 1 OF POTASH IN THE ROOTS.

| Plot. | Standard manures. | Series 1. Without nitrogenous manure. | Series 2. With sodium nitrate. | Series 3. With ammonium-salts. | Series 4. With rape-cake and ammonium salts | Series 5. With rape-cake |
|---|---|---|---|---|---|---|
| 5 | Superphosphate . | 34.0 | 52.4 | 46.3 | 35.3 | 38.7 |
| 6 & 4 | Superphosphate, and potash, &c. | 23.4 | 21.9 | 17.5 | 14.7 | 17.5 |

## *Condition of the Nitrogen in Roots.*

An important point yet to consider is the amount and the condition of the nitrogen in roots of different descriptions, or grown under different conditions.

*Albuminoids and amides.* As is well known, in perfectly ripened seeds by far the larger proportion, and in many cases nearly the whole, of the nitrogen exists as albuminoids. In ripened products, however, some, and in unripened ones sometimes a large proportion, of the nitrogen exists as amides. Now, so far as present knowledge goes, it seems probable that it is only the nitrogen existing as albuminoid compounds that can contribute to the formation of the albuminoid compounds of animal bodies, or of milk. It would seem not improbable, however, that some amide compounds may replace the albuminoids in supplying material for the transformations incident to the constant waste of the nitrogenous substances of the body, the products of which pass from it in the urine.

*Nitric acid and ammonia.* Then, again, besides albuminoids and amides, succulent or immature vegetable products may contain nitrogen as nitric acid, or as ammonia, unchanged from the condition in which it has been taken up by the roots of the plant from the soil, or the one transformed into the other.

The question as to the condition of the nitrogen in vegetable foods, and especially in such crude and immature

products as our feeding roots, is therefore one of great importance. In the early reports of the Rothamsted feeding experiments, published more than forty years ago, we called attention to the fallacy of estimating the whole of the nitrogen of our stock-foods as protein or albuminoid compounds, especially in the case of succulent and unripened products.

*Swedes.* Table 19 (p. 64) gives results as to the condition of the nitrogen in Swedish turnips grown in the experimental rotation at Rothamsted in 1880; also in the mangels grown in the experiments in 1878, 1879, and 1880.

*Without manure.* It should be explained that one portion of the rotation land has been entirely unmanured throughout, and that the roots so grown are quite abnormal, none of the characters of the cultivated root being developed under these circumstances. The results given relate to the roots grown in 1880 as the first crop of the ninth course. It is seen that with an abnormally high percentage of total nitrogen in the roots (0.347 in the fresh, and 2.758 in the dry), there was also a high percentage of albuminoid nitrogen; which corresponded, however, to only 32.9 per cent of the total nitrogen.

*Superphosphate alone.* The next plot had received, for the roots, superphosphate of lime alone. Under these conditions the roots of the ninth course show a very low percentage of nitrogen in their dry substance (0.984), but 59.1 per cent of it existed as albuminoid compounds.

*Complex manure.* Lastly, the third plot received for the roots of each course a complex manure, both mineral and nitrogenous. The percentage of total nitrogen in the dry substance of the roots (1.539), though not high, was nevertheless more than one and a-half time as high as in the case of the roots grown by superphosphate alone; and the proportion of the nitrogen which was as albuminoids was only 42.5 per cent.

*Manure and soluble nitrogen in roots.* Then, again, it is seen that in the cultivated roots by far the larger proportion of the albuminoid nitrogen existed in the juice—that is to say, was soluble, whilst in the unmanured or, so to speak, uncultivated roots, a comparatively small proportion of the total albuminoids existed in the juice.

*Influence of manuring on feeding value of foods.* These results with Swedish turnips are very instructive, as showing how very dependent is the proportion of the nitrogen existing in the favourable food-condition of albuminoid compounds, on the conditions of the manuring, and on the maturity of the crop.

*Mangels; influence of season and manure.* In the results relating to the mangels the influence of season as well as of manure on the condition of the nitrogen is illustrated.

TABLE 19.—SHOWING THE CONDITION OF THE NITROGEN IN SWEDISH TURNIPS AND IN MANGEL-WURZEL.

| | Total nitrogen. | | Albuminoid nitrogen. | | Per cent of the total nitrogen. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | As albuminoids. | | | As amides. | As nitric acid. | Other forms. | Total. |
| | In fresh roots. | In dry matter. | In fresh roots. | In dry matter. | In marc. | In juice. | Total. | | | | |
| **ROTATION SWEDES, SEASON 1880.** | | | | | | | | | | | |
| | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. | per cent | per cent. | per cent. | |
| Unmanured | 0.347 | 2.758 | 0.114 | 0.906 | 21.1 | 11.8 | 32.9 | ? | ? | 67.1 | 100 |
| Superphosphate | 0.120 | 0.984 | 0.072 | 0.590 | 26.8 | 32.3 | 59.1 | ? | ? | 40.9 | 100 |
| Mixed manure | 0.171 | 1.539 | 0.073 | 0.655 | 18.1 | 24.4 | 42.5 | ? | ? | 57.5 | 100 |
| **MANGEL-WURZEL, 1878 (MINERAL MANURES AND RAPE-CAKE).** | | | | | | | | | | | |
| Superphosphate | 0.211 | 1.520 | 0.075 | 0.541 | 14.2 | 21.3 | 35.5 | ? | ? | 64.5 | 100 |
| Superphosphate and potassium sulphate | 0.197 | 1.618 | 0.067 | 0.555 | 17.3 | 16.9 | 34.2 | ? | ? | 65.8 | 100 |
| Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 0.171 | 1.525 | 0.045 | 0.401 | 8.8 | 17.4 | 26.2 | ? | ? | 73.9 | 100 |
| **MANGEL-WURZEL, 1879 (MINERAL MANURES AND RAPE-CAKE).** | | | | | | | | | | | |
| Superphosphate | 0.182 | 1.166 | 0.079 | 0.507 | 23.1 | 20.1 | 43.2 | ? | 3.9 | 52.9 | 100 |
| Superphosphate and potassium sulphate | 0.157 | 1.087 | 0.071 | 0.492 | 24.9 | 20.5 | 45.4 | ? | 10.3 | 44.3 | 100 |
| Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 0.136 | 1.010 | 0.060 | 0.444 | 21.3 | 23.0 | 44.3 | ? | 13.3 | 42.4 | 100 |
| **MANGEL-WURZEL, 1880 (MINERAL MANURES AND RAPE-CAKE).** | | | | | | | | | | | |
| Superphosphate | 0.165 | 1.344 | 0.068 | 0.554 | 20.0 | 21.0 | 41.0 | 40.5 | 11.2 | 7.3 | 100 |
| Superphosphate and potassium sulphate | 0.151 | 1.145 | 0.073 | 0.554 | 24.5 | 23.9 | 48.4 | 38.9 | ? | 12.7 | 100 |
| Superphosphate, potassium, and magnesium sulphates, and sodium chloride | 0.123 | 1.099 | 0.056 | 0.501 | 22.8 | 23.1 | 45.9 | 38.8 | 10.8 | 4.5 | 100 |

Three plots were selected for investigation, which, with pretty full amounts of produce, would give roots of fairly good degree of maturation—namely, those manured with rape-cake in addition to various mineral manures.

In 1878 there were somewhat under-average crops, with a large proportion of leaf—conditions indicative of comparative immaturity. Under these circumstances the percentage of total nitrogen in the roots was not high, but the proportion of the total nitrogen existing as albuminoids was low—namely, 35.5 and 34.2 per cent in two cases, and only 26.2 per cent in the third; but in this last case it was concluded that the determination was too low.

In the very wet and cold season of 1879 the crops were very small, and the percentage of total nitrogen was low; the result being doubtless partly due to loss of nitrogen by drainage. Under these circumstances the amounts of the total nitrogen found as albuminoids were 43.2, 45.4, and 44.3 per cent, or an average of about 44 per cent.

In 1880 the crops were much above the average, and the percentage of total nitrogen was low; and there was again, under the better conditions as to mineral manuring—that is, where potash was applied—more than 47 per cent of the total nitrogen albuminoid.

*Percentage of amides.* The bottom division of the table shows that in the crops of 1880, in which alone the amides were determined, the proportion of the nitrogen in that condition was about, or rather less than, 40 per cent of the total nitrogen, and not much less than that of the albuminoid nitrogen. It may be stated that according to results given by Messrs Ivey and Gray, the average composition of eleven New Zealand specimens of common turnips showed that the proportion of the nitrogen reckoned as "amides, &c." (including extractive matter) was 50.1 per cent of the total nitrogen; which is rather more than was found as albuminoids in the same roots, and more than was found as amides in the Rothamsted mangels.

*Nitric acid.* In all three cases in 1879, and in two in 1880, the amount of the nitrogen existing as nitric acid was determined. It is seen that, with one exception, in which the nitrogen as nitric acid amounted to only 3.9 per cent of the total nitrogen, it ranged from 10 to 13 per cent of the total. Compared with these amounts, Messrs Ivey and Gray found less than 1 per cent of the total nitrogen of the common turnips to exist as nitric acid, and not much more than 1 per cent as ammonia. It may be added that in some determinations made at Rothamsted in swedes the proportion of the total nitrogen as nitric acid was very much less than in the mangels.

*Different forms of nitrogen in mangels and turnips.*

Upon the whole, so far as the evidence at command enables us to judge, there is in mangels—with their more extended root-range, greater power of accumulation, more luxuriant growth, and frequent greater immaturity when taken up—a somewhat less proportion of the total nitrogen in the albuminoid condition than in either common turnips or swedes. There is also probably in mangels a less proportion of amide nitrogen, and pretty certainly a larger proportion of nitrogen as nitric acid, and in other forms.

### *Approximate average percentage of Dry Matter and of Sugar in various Roots.*

It has been stated that root-crops, as grown for stock-food, are essentially *sugar crops.*

Not only, however, do the various descriptions of roots differ much in composition one from another, but the composition of one and the same description will vary very greatly under different conditions of growth and of maturity of the roots accordingly. It will, nevertheless, be useful to give such an estimate as the evidence at command permits of the approximate average percentages of dry matter, and of sugar, in different descriptions of feeding roots.

TABLE 20.—Estimates of the Approximate Average Percentages of Dry Matter and of Sugar in different descriptions of Roots.

| | Dry matter. | Sugar. | |
|---|---|---|---|
| | | In fresh roots. | In dry matter. |
| | Per cent. | Per cent. | Per cent. |
| White turnips . . . | 8.0 | 3.5 to 4.5 | 44 to 56 |
| Yellow turnips . . . | 9.0 | 4.0 " 5.0 | 44 " 56 |
| Swedish turnips . . . | 11.0 | 6.0 " 7.0 | 55 " 64 |
| Mangel-wurzel . . . | 12.5 | 7.5 " 8.5 | 60 " 68 |

*Sugar in root-crops.*

Thus, then, even in common turnips, one-half or more of the total solid matter of the roots may be sugar. Of the total dry matter of Swedish turnips a larger proportion, and of that of mangels a larger proportion still, will be sugar; indeed in well-matured mangels about two-thirds of the total solid matter may be sugar.

*Albuminoid-ratio in cereals and roots.*

It may be assumed that in the cereal grains the proportion of albuminoid matter to the non-nitrogenous food material (starch, &c.) averages about as 1 to 6 (more or less); and that this is a proportion which is, as a rule, fairly favourable

for the requirements of fattening animals. In roots the albuminoid ratio varies very greatly; but it is probably seldom more than as 1 to 12, and frequently as low as 1 to 20 or more. The ratio will generally be lower in swedes than in common turnips, and lower still in mangels.

*Necessity for mixed foods.*

It is obviously very essential to give with roots other foods which are richer in albuminoid substances, and which contain a higher proportion of albuminoid to digestible non-nitrogenous matters. Nevertheless roots are, by virtue of the amount of sugar they supply, very valuable for meeting the respiratory requirements of the animals, also for fat-forming, and for milk-production, when given in due admixture.

### *General Conclusions.*

From all the illustrations that have been adduced, it will be obvious that both the quantity and quality of the produce, and consequently its feeding value, will greatly depend on the selection of the best description of roots to be grown, and on the character and the amount of the manures, and especially on the amount of nitrogenous manure, to be employed. It will at the same time be obvious that no hard and fast lines can be laid down in regard to these points. Independently of the necessary consideration of the general economy of the farm, the choice must be influenced partly by the character of the soil, but very much more by that of the climate. Judgment, founded, it is true, on knowledge, and aided by careful observation, both in the field and in the feeding-shed, must be relied upon as the guide of the practical farmer.

Lastly, independently of the great advantage arising from the opportunity which the growth of roots affords for the cleaning of the land, the benefits of growing the crop in rotation are due—to the large amount of manure applied for its growth, to the large residue of the manure left in the soil for future crops, to the large amount of matter at once returned as manure again in the leaves, to the large amount of food produced, and to the small proportion of the most important manurial constituents of the roots which is retained by store or fattening animals consuming them, the rest returning as manure again; though, when roots are used for the production of milk, a much larger proportion of the constituents is lost to the manure.

## *SECTION II.—EXPERIMENTS WITH BARLEY GROWN CONTINUOUSLY; HOOSFIELD, ROTHAMSTED.*

### INTRODUCTION.

We have now to consider results obtained at Rothamsted on the growth of barley, for more than forty years in succession on the same land. The results of some laboratory investigations in connection with barley will also be adduced.

Barley, like wheat, is, as is well known, a member of the great Gramineous Order of plants, to which we owe so many and such important economic products. In our own country and climate, barley comes second to wheat in importance among the cereal crops we cultivate; though, in the north, oats gain in relative consideration.

*Various gramineous crops.*

Over large areas of America, with warmer and longer summers, another gramineous grain-crop, maize, comes into prominence; and in warmer localities still, grows the sugar-cane. Indeed it is to this family that we owe our chief *starch-* and *sugar*-yielding crops; and it is somewhat remarkable that the plants which, at any rate in temperate climates, come next in importance as starch- and sugar-yielding crops, should belong to such widely different Orders as the Solaneæ giving us the potato, the Cruciferæ turnips, and the Chenopodiaceæ the sugar-beet, mangel-wurzel, &c.; whilst the organs, or parts of the plants which yield the products, are also very different. In each case, however, it is the store of reserve-material which the plant has accumulated for reproduction, or for further growth, which we turn to economic account.

But not only does the gramineous family provide us with very important starch- and sugar-yielding crops, but it contributes a large proportion of the natural and cultivated herbage, upon which animals of use to man are fed over large portions of the globe.

*Wheat and barley compared.*

Although *wheat* and *barley* are thus closely allied botanically, and they have, moreover, in some respects very similar requirements as cultivated crops, yet it will be found that there are distinctions as well as similarities, which it is important to recognise.

In our own country and climate, at any rate, wheat is almost invariably sown in the autumn, whilst barley is as generally not sown until the spring. Thus wheat has four or five months for root-development, and for gaining possession of range of soil, before barley is sown. Under these circumstances, too, the conditions of soil most suitable to the two

crops are very different. For wheat a comparatively heavy soil is adapted; and a fine tilth, encouraging superficial root-development, is not desirable. For barley, on the other hand, a comparatively light soil is more appropriate, and a fine tilth is of great importance. In other words, with the characteristic habit of growth of the plant, and the short period at its command for root-development, a very permeable surface-soil is a desideratum.

*Root-ranges of wheat and barley.*

In these facts we have the indication that wheat acquires a much greater root-range, and consequently a command of the resources of a more extended range of both soil and subsoil; whilst barley must, in a greater degree, be dependent on the supplies within the surface-soil, and so be the more susceptible to the influence of the exhaustion, or the supplies, within the surface-soil.

Bearing these various points in mind, we may now turn to the results of long-continued field experiments on the growth of barley, by different manures, and in different seasons, and to the evidence of the collateral laboratory investigations relating to the subject.

### *The Field Experiments on Barley.*

*Rothamsted experiments on barley.*

The Rothamsted field experiments on barley were commenced in 1852—that is, eight years later than those on wheat, but at the same time as that at which the arrangement of the plots in the experimental wheat-field devoted to chemical or artificial manures became more systematic and permanent.

*Plan of the experiments.*

The barley crop of 1894 was, therefore, the forty-third in succession on the same land. There are nearly thirty experimental plots. Two have been unmanured from the commencement. One has received farmyard manure every year, or rather one-half of it has, for, after twenty years, the plot was divided; one half being still annually manured as before, and the other half then left unmanured, to test the effects of the unexhausted residue of the twenty years' previous applications of farmyard manure. The other plots have annually received artificial manures, for the most part the same year after year from the commencement; but there have been a few changes, some of which will be explained as we proceed.

### *Results without Manure, and with Farmyard Manure.*

*Table 21 explained.*

Table 21 (p. 70) gives, both without manure and with farmyard manure, the produce of grain per acre in each of the forty-

TABLE 21.—BARLEY 43 YEARS IN SUCCESSION ON THE SAME LAND. Produce—Without Manure, and with Farmyard Manure. Dressed Grain per acre, bushels.

| | Unmanured every year. | Farmyard Manure. Every year, 1852-94. | Farmyard Manure. Twenty years, 1852-71; unmanured, 1872-94. | Farmyard Manure. Plot 7-1 less than Plot 7-2. | More than unmanured. Manured every year. | More than unmanured. Manured 20 years, unmanured afterwards. |
|---|---|---|---|---|---|---|
| | Plot 1-0. | Plot 7-2. | Plot 7-1. | | Plot 7-2. | Plot 7-1. |
| | Bushels. | Bushels. | | Bushels. | Bushels. | |
| 1852 . . | 27¼ | 33 | | .. | + 5¾ | |
| 1853 . . | 25¾ | 36⅛ | | .. | +10⅜ | |
| 1854 . . | 35 | 56⅜ | | .. | +21⅜ | |
| 1855 . . | 31 | 50⅛ | | .. | +19⅛ | |
| 1856 . . | 13⅞ | 32⅛ | | .. | +18¼ | |
| 1857 . . | 26⅛ | 51¼ | | .. | +25⅛ | |
| 1858 . . | 21⅛ | 55 | | .. | +33⅞ | |
| 1859 . . | 13½ | 46 | | .. | +26½ | |
| 1860 . . | 13¼ | 41⅝ | | .. | +28⅜ | |
| 1861 . . | 16¼ | 54⅜ | | .. | +38⅛ | |
| 1862 . . | 16¼ | 49¼ | | .. | +33¼ | |
| 1863 . . | 22⅞ | 59½ | | .. | +36⅝ | |
| 1864 . . | 24 | 62 | | .. | +38 | |
| 1865 . . | 18 | 52¾ | | .. | +34⅞ | |
| 1866 . . | 15⅞ | 53⅛ | | .. | +37¼ | |
| 1867 . . | 17⅛ | 45⅝ | | .. | +28½ | |
| 1868 . . | 15⅝ | 43⅝ | | .. | +28 | |
| 1869 . . | 15⅛ | 46⅞ | | .. | +31¾ | |
| 1870 . . | 13½ | 47½ | | .. | +34 | |
| 1871 . . | 16¾ | 54¼ | | .. | +37½ | |
| 1872 . . | 10¼ | 38⅞ | 38¼ | −0⅝ | +28⅝ | +28 |
| 1873 . . | 14 | 54¼ | 47½ | −6¾ | +40¼ | +33½ |
| 1874 . . | 17⅝ | 64½ | 46½ | −18 | +46⅞ | +28⅞ |
| 1875 . . | 12½ | 45¼ | 32½ | −12¾ | +32¾ | +20 |
| 1876 . . | 12¾ | 45 | 31 | −14 | +32¼ | +18¼ |
| 1877 . . | 17⅛ | 52 | 36 | −16 | +34⅞ | +18⅞ |
| 1878 . . | 10 | 46¼ | 21⅞ | −24⅜ | +36¼ | +11⅞ |
| 1879 . . | 6¼ | 36⅝ | 16⅝ | −20 | +30⅜ | +10⅜ |
| 1880 . . | 18⅞ | 65¼ | 41⅝ | −23⅝ | +46⅜ | +22¾ |
| 1881 . . | 17⅞ | 53¾ | 29¾ | −24 | +35⅞ | +11⅞ |
| 1882 . . | 18⅛ | 60¾ | 35 | −25¾ | +42⅜ | +16⅞ |
| 1883 . . | 16¼ | 58½ | 35½ | −23 | +42¼ | +19¼ |
| 1884 . . | 13¾ | 57¼ | 29 | −28¼ | +43⅜ | +15¼ |
| 1885 . . | 9¼ | 49¼ | 22 | −27¼ | +40 | +12¾ |
| 1886 . . | 11 | 41¼ | 30½ | −10¾ | +30¼ | +19½ |
| 1887 . . | 7½ | 26 | 10 | −16 | +18½ | + 2½ |
| 1888 . . | 12¼ | 45 | 24⅜ | −20⅝ | +32¾ | +12⅛ |
| 1889 . . | 11¼ | 42 | 22¼ | −19¾ | +30¾ | +11 |
| 1890 . . | 13 | 53 | 22⅛ | −30⅞ | +40 | + 9⅛ |
| 1891 . . | 15½ | 43¾ | 33⅝ | −10⅛ | +28½ | +18⅛ |
| 1892 . . | 14 | 59¾ | 30¾ | −29 | +45¾ | +16¾ |
| 1893 . . | 8½ | 43½ | 20¼ | −23¼ | +35½ | +12 |
| 1894 . . | 10 | 44⅝ | 23¾ | −20⅞ | +34⅝ | +13¾ |

AVERAGES.

| | Unmanured every year. | Every year, 1852-94. | Twenty years, 1852-71; unmanured, 1872-94. | Plot 7-1 less than Plot 7-2. | Manured every year. | Manured 20 years, unmanured afterwards. |
|---|---|---|---|---|---|---|
| 8 years, 1852-59 . . . | 24¼ | 44½ | | .. | +20 | |
| 8 years, 1860-67 . . . | 18 | 52⅜ | | .. | +34⅜ | |
| 8 years, 1868-75 . . . | 14½ | 40½ | 44⅝ | (−9½) | +34⅞ | +30⅛ |
| 8 years, 1876-83 . . . | 14⅝ | 52¼ | 31 | −21¼ | +37⅝ | +16¼ |
| 8 years, 1884-91 . . . | 11¾ | 44⅝ | 24¼ | −20⅝ | +33 | +12⅝ |
| 20 years, 1852-71 . . . | 20 | 48¼ | | .. | +28¼ | |
| 20 years, 1872-91 . . . | 13¼ | 49 | 30¼ | −18¾ | +35¾ | +17 |
| 40 years, 1852-91 . . . | 16½ | 48⅝ | 39¼ | .. | +32⅛ | +22¾ |
| Last 20 years, per cent + or − first 20 years | −33.8 | +1.6 | −37.3 | .. | .. | .. |

three years, and also the average produce over selected series of years, and over the period of forty years, to 1891 inclusive.

The first column gives the produce without manure. The upper portion of columns 2 and 3 gives the produce by farmyard manure for the first twenty years (1852-1871) over the whole plot. The lower portion of column 2 gives the produce on the half of the plot on which the application was still continued; and that of column 3 the produce on the other half where the application was discontinued after the first twenty years, showing therefore the effects of the residue of the previous applications. Column 4 shows, for the later years, the deficiency of the produce on the plot where the application was discontinued compared with that where it was continued; and the last two columns show the increase over the unmanured produce—first by farmyard manure continuously applied, and secondly by the residue of the applications of the first twenty years.

*Produce without manure.*

First referring to the produce *without manure,* it is seen that in two years, the third and fourth, the yield was over 30 bushels per acre; in six years during the first thirteen it was between 20 and 30 bushels, but it never afterwards reached 20 bushels, and in thirty-two out of the forty years the yield was less than 20 bushels; in eighteen of these it was less than 15, and in three less than 10 bushels.

*Influence of seasons.*

There was thus a very great variation in the amount of produce without manure from year to year according to season. A glance at the figures, and especially at the average produce over successive series of years, as given at the foot of the table, shows, however, that independently of these fluctuations due to season, there was a progressive decline due to exhaustion.

*Exhaustion in surface-soil.*

It may be observed that there is, without manure, a decline in the produce of barley-grain of 33.8 per cent over the second twenty years compared with the first twenty; and that this rate of decline is considerably greater than was found in the case of wheat. This result is doubtless due to the shorter period of growth, and the greater dependence on the surface-soil, in the case of barley; and hence exhaustion is the sooner manifested.

*Farmyard manure.*

Turn now to the produce by *farmyard manure.* As without manure, there is very great fluctuation from year to year according to season; but instead of a gradual decline, there is an increase in the yield over the later years due to the accumulation of the manure. There is, in fact, instead of a decline of 33.8 per cent as without manure over the second compared with the first twenty years, an increase with farmyard manure of 1.6 per cent over the later period.

In four of the forty years the farmyard manure gave more

than 60 bushels of barley per acre, in fifteen years between 50 and 60 bushels, in fifteen between 40 and 50 bushels, in five between 30 and 40 bushels, and in only one year below 30 bushels. The average yield was, over the first twenty years 48¼ bushels, over the second twenty 49 bushels, and over the forty years 48⅝ bushels, against 16½ bushels without manure.

*Nitrogen supplied in the dung.*

So much for the produce of barley obtained by the unusual application of 14 tons of farmyard manure per acre per annum for forty years in succession. It is estimated that the manure supplied about 200 lb. of nitrogen per acre per annum, or over twenty years 4000 lb. of nitrogen. It is further estimated that, at the end of the first twenty years, not more than 14 or 15 per cent of this large amount of nitrogen had been removed in the increase of crop. There must, therefore, have been a great accumulation of nitrogen, and of other constituents, within the soil; and analysis proved that this was the case. Indeed, it was calculated that, if there were no loss of nitrogen, by drainage, by evolution of free nitrogen, or otherwise, and if the accumulated residue were as available as that which had already been effective, the produce should be maintained at the level of that of the first twenty years for nearly 150 years more!

*Nitrogen stored in the soil.*

*Dung stopped after twenty years.*

Let us see what was the result of stopping the application of manure on half the plot after the first twenty years? This is shown in the lower half of the table. Comparing the second and third columns, it is seen that there was a tendency to increase in yield where the application of the farmyard manure was continued, and to decrease where it was discontinued. This result is brought prominently to view in column 4, which shows the reduction in the amount of produce on the *manure-residue* plot compared with that where the application was continued.

The averages at the foot of the table show that over the first twenty years, with the continuous application, the yield was 48¼ bushels, whilst over the succeeding twenty years it was, where the application was continued 49 bushels, but where it was discontinued only 30¼ bushels; showing, therefore, an average annual deficiency under the influence of the residue only, of 18¾ bushels, or of 38.3 per cent.

*Increase over no-manure plot.*

Taking as the standard of comparison the unmanured produce (which, however, itself gradually declined), the last two columns show that over the first twenty years there was an average annual increase of 28¼ bushels by the application of the farmyard manure; and that over the second twenty years there was an average annual increase of 35¾ bushels where the application was continued, and of only 17 bushels where it was discontinued.

It may be observed that, over the whole period of forty years, the total produce (grain and straw together) was without manure less than 1 ton per acre per annum, whilst with the farmyard manure it was 2¾ tons, and in some years it reached from 3½ to 3¾ tons.

*Summary of results with dung and no manure.* To sum up in regard to the foregoing results: There was gradual exhaustion and reduction of produce without manure, and gradual accumulation and increase of produce with the annual application of farmyard manure. But when the application was stopped, although the effect of the residue from the previous applications was very marked, it somewhat rapidly diminished, notwithstanding that calculation showed an enormous accumulation of nitrogen as well as other constituents.

*Accumulated nitrogen, and what becomes of it.* Indeed, determinations of nitrogen in the surface-soil, after the twenty years' application of farmyard manure, showed it to be nearly twice as high as on the unmanured plot.

How, then, is the reduction of produce to be accounted for? The nitrogen of farmyard manure must obviously exist in very different conditions. That due to the urine of the animals will be the most rapidly available, that in the finely comminuted matter in the fæces will be much more slowly available, and that in the litter still more slowly available. Hence the small proportion that is at once effective, and the very large amount that accumulates within the soil in a very slowly available condition.

*Loss of soil nitrogen.* But the evidence at command leads to the conclusion that neither in the wheat-field nor in the barley-field does the accumulation within the soil account for the whole of the nitrogen supplied which is not recovered in the immediate increase of crop. Some is doubtless lost as nitrates by drainage, and some probably by evolution as free nitrogen. The fact of such losses is of considerable interest; but it is some consolation to believe that the loss will be proportionally very much less in ordinary farm practice, where the amounts of farmyard manure applied are much less, and where various crops, with different root-ranges, and different periods of accumulation, are grown.

### *Results without Manure, and with Artificial Manures.*

*Tables 22 and 23 explained.* We have next to consider—what is the character of the exhaustion induced by the growth of the crop without manure? and to what constituent or constituents of farmyard manure its effects are mainly to be attributed? These points will be illustrated by the results given in Tables 22 and 23 (pp. 74 and 75), which show the effect of various mineral

TABLE 22.—BARLEY 43 YEARS IN SUCCESSION ON THE SAME LAND. Dressed Grain per acre, bushels. Manure and Produce per acre per annum.

| | Series 1. | | | | Series 2. 200 lb Ammonium-salts=43 lb. N. | | | |
|---|---|---|---|---|---|---|---|---|
| | Unmanured. | Superphosphate. | Potassium, sodium, and magnesium sulphates | Mixed mineral manure (2 and 3 mixed). | Alone. | And superphosphate. | And potassium, sodium, and magnesium sulphates. | And mixed mineral manure (2 and 3 mixed). |
| | Plot 1. | Plot 2. | Plot 3. | Plot 4 | Plot 1. | Plot 2. | Plot 3. | Plot 4. |
| | Bushels. | Bushels. | Bushels. | Bushels. | Bushels. | Bushels | Bushels. | Bushels. |
| 1852 | 27¼ | 28⅝ | 26⅛ | 32¾ | 36⅞ | 38⅝ | 36 | 40¾ |
| 1853 | 25¾ | 33½ | 27⅝ | 35⅝ | 38⅝ | 40⅛ | 30½ | 38½ |
| 1854 | 35 | 40⅝ | 36½ | 42 | 47¾ | 60½ | 50 | 60⅝ |
| 1855 | 31 | 36½ | 34¾ | 37⅛ | 44½ | 47¾ | 44½ | 48⅜ |
| 1856 | 13⅞ | 17¾ | 16⅝ | 19¾ | 25 | 29⅛ | 28⅜ | 31¾ |
| 1857 | 26⅛ | 33¼ | 32 | 39¾ | 38⅞ | 56½ | 42⅜ | 57⅜ |
| 1858 | 21⅛ | 28¾ | 24¼ | 30⅞ | 31½ | 51⅜ | 34¼ | 51⅛ |
| 1859 | 13½ | 19⅝ | 15⅞ | 19¾ | 15⅜ | 34½ | 16⅞ | 34⅜ |
| 1860 | 13¼ | 15¾ | 15¼ | 18¼ | 26⅝ | 48⅜ | 28 | 48½ |
| 1861 | 16¼ | 25 | 18⅞ | 29⅜ | 30⅛ | 55 | 32¾ | 54⅜ |
| 1862 | 16½ | 21⅞ | 19¾ | 25⅛ | 31⅝ | 48⅝ | 35¼ | 47⅝ |
| 1863 | 22⅞ | 32⅜ | 27⅝ | 33 | 42⅝ | 61⅝ | 48⅝ | 55⅜ |
| 1864 | 24 | 30½ | 26⅛ | 33¼ | 38⅞ | 58½ | 48⅞ | 55⅝ |
| 1865 | 18 | 22½ | 22 | 24⅝ | 29⅞ | 48⅜ | 33½ | 46½ |
| 1866 | 15⅞ | 22⅜ | 19⅛ | 24 | 27⅛ | 50½ | 27½ | 47 |
| 1867 | 17⅛ | 24⅝ | 17 | 20⅞ | 30⅝ | 44 | 33 | 43⅞ |
| 1868 | 15⅝ | 18⅛ | 14¼ | 17⅝ | 20⅜ | 37⅝ | 25 | 34⅝ |
| 1869 | 15¼ | 18¼ | 18¾ | 22¼ | 27⅞ | 48 | 34¾ | 49¼ |
| 1870 | 13½ | 18 | 16¾ | 18½ | 27¾ | 41⅛ | 30⅞ | 38 |
| 1871 | 16¾ | 23⅛ | 19⅝ | 25 | 36⅜ | 45⅛ | 38⅛ | 46½ |
| 1872 | 10¼ | 15⅜ | 10½ | 14¼ | 26¼ | 39⅜ | 30⅜ | 36⅞ |
| 1873 | 14 | 19⅞ | 14⅞ | 20⅜ | 32⅜ | 50⅞ | 34⅛ | 46⅞ |
| 1874 | 17⅝ | 21¼ | 17⅞ | 19⅛ | 23¼ | 42⅜ | 30⅝ | 45¾ |
| 1875 | 12½ | 14⅜ | 14⅞ | 17½ | 27⅜ | 37 | 29¼ | 35⅞ |
| 1876 | 12⅝ | 16⅛ | 12⅝ | 15⅝ | 21 | 33¼ | 23⅜ | 35⅝ |
| 1877 | 17⅛ | 23⅞ | 20⅛ | 28¾ | 35⅛ | 43⅞ | 41½ | 50⅛ |
| 1878 | 10 | 12⅛ | 7¾ | 11⅜ | 14⅞ | 31⅛ | 20⅛ | 33⅜ |
| 1879 | 6¼ | 7¾ | 6⅛ | 7¼ | 15¾ | 27⅞ | 16[illegible] | 27⅛ |
| 1880 | 18⅞ | 28⅝ | 23⅞ | 30⅛ | 33⅞ | 55⅝ | 38⅛ | 51⅝ |
| 1881 | 17⅞ | 19¼ | 17⅛ | 17⅞ | 33⅛ | 43⅝ | 37[illegible] | 42⅝ |
| 1882 | 18⅜ | 21⅞ | 19 | 23⅜ | 34⅞ | 45½ | 39½ | 50⅜ |
| 1883 | 16¼ | 22⅝ | 18⅝ | 24⅛ | 38⅞ | 49⅛ | 43⅜ | 52 |
| 1884 | 13¾ | 17⅝ | 13⅛ | 14¾ | 26½ | 29 | 31 | 42¼ |
| 1885 | 9¼ | 12⅛ | 7⅞ | 12½ | 15⅛ | 29 | 15⅛ | 32 |
| 1886 | 11 | 15⅝ | 11⅞ | 11½ | 24½ | 37¼ | 19⅝ | 35⅞ |
| 1887 | 7⅛ | 9⅜ | 6⅝ | 8⅝ | 13⅛ | 22⅛ | 16 | 27⅝ |
| 1888 | 12¼ | 20 | 13¼ | 18¾ | 20⅛ | 34¼ | 20 | 43⅜ |
| 1889 | 11¼ | 20 | 9 | 17½ | 22⅛ | 35¼ | 19⅛ | 35¾ |
| 1890 | 13 | 16¾ | 9¾ | 17¾ | 24½ | 33½ | 23⅜ | 40⅝ |
| 1891 | 15¼ | 20¾ | 14⅜ | 20 | 29¼ | 51⅜ | 20 | 46½ |
| 1892 | 14 | 20¾ | 15⅛ | 21⅝ | 26¼ | 51 | 33⅞ | 50⅝ |
| 1893 | 8¼ | 11¾ | 7¾ | 10 | 11⅝ | 18⅛ | 16¼ | 30¼ |
| 1894 | 10 | 16¾ | 9½ | 13⅛ | 10½ | 34⅞ | 17¾ | 41⅜ |

AVERAGES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 years, 1852-59 | 24¼ | 29¾ | 26¾ | 32¼ | 34⅞ | 44⅞ | 36⅛ | 45⅜ |
| 8 years, 1860-67 | 18 | 24⅜ | 20¾ | 26 | 32⅛ | 51⅛ | 35¼ | 49½ |
| 8 years, 1868-75 | 14½ | 18⅝ | 15⅞ | 19⅜ | 27¾ | 42¾ | 31⅜ | 41¾ |
| 8 years, 1876-83 | 14⅝ | 19 | 15⅝ | 19¼ | 28½ | 41¼ | 32¼ | 43⅛ |
| 8 years, 1884-91 | 11¼ | 16⅛ | 10¾ | 15¼ | 22 | 34 | 21⅜ | 38⅛ |
| 20 years, 1852-71 | 20 | 25½ | 22⅛ | 27⅛ | 32⅛ | 47 | 35 | 46½ |
| 20 years, 1872-91 | 13¼ | 17¾ | 13⅛ | 17¼ | 25⅝ | 38½ | 27¾ | 40¾ |
| 40 years, 1852-91 | 16⅝ | 21¾ | 18 | 22⅜ | 29 | 42¾ | 31⅜ | 43½ |
| Last 20 yrs., per cent + or − first 20 yrs. | −33.8 | −30.4 | −40.0 | −37.3 | −21.2 | −18.1 | −20.7 | −11.9 |

TABLE 23.—BARLEY, 43 YEARS IN SUCCESSION ON THE SAME LAND. Dressed Grain per acre, bushels. Manures and Produce per acre per annum.

| | Series 3. 275 lb. sodium nitrate=43 lb. N.[1] | | | | Series 4. 1000 lb. rape-cake=49 lb. N.[2] | | | |
|---|---|---|---|---|---|---|---|---|
| | Alone. | Super-phosphate. | Potassium, sodium, and magnesium sulphates | Mixed mineral manure (2 and 3 mixed). | Alone. | And super-phosphate. | And potassium, sodium, and magnesium sulphates | Mixed mineral manure (2 and 3 mixed). |
| | Plot 1. | Plot 2. | Plot 3. | Plot 4. | Plot 1. | Plot 2. | Plot 3. | Plot 4. |
| | Bushels. | Bushels | Bushels. | Bushels. | Bushels. | Bushels. | Bushels. | Bushels. |
| 1852 | 44½ | 43¾ | 41¾ | 45⅛ | 39⅛ | 36⅛ | 33½ | 38 |
| 1853 | 40¾ | 42¼ | 41¼ | 44½ | 39⅞ | 36¼ | 35¼ | 40⅛ |
| 1854 | 56⅝ | 63¼ | 51½ | 62¾ | 60¼ | 60⅜ | 56½ | 60¼ |
| 1855 | 48 | 50⅜ | 47¼ | 49⅝ | 48½ | 53½ | 48⅞ | 51¾ |
| 1856 | 36¼ | 31½ | 25⅜ | 37⅝ | 36¼ | 37⅛ | 32⅝ | 35⅜ |
| 1857 | 49¾ | 66½ | 49⅞ | 64⅞ | 64⅛ | 62¼ | 60¼ | 62¼ |
| 1858 | 39⅜ | 56¼ | 40⅝ | 56½ | 53¼ | 57⅛ | 52 | 57⅛ |
| 1859 | 21½ | 35⅞ | 20⅜ | 35¾ | 38¼ | 41 | 34⅛ | 35 |
| 1860 | 25⅜ | 43¼ | 30¾ | 46¼ | 31¾ | 36¾ | 35¼ | 40⅜ |
| 1861 | 35 | 55¾ | 36⅞ | 55⅞ | 56½ | 56⅞ | 51⅛ | 53⅝ |
| 1862 | 31½ | 51 | 36¼ | 48¾ | 41 | 45 | 36 | 45½ |
| 1863 | 49 | 60½ | 54 | 59½ | 51⅞ | 55 | 53⅛ | 54½ |
| 1864 | 41¾ | 56⅞ | 44⅝ | 56⅜ | 48⅛ | 51¾ | 49⅜ | 53 |
| 1865 | 33¾ | 47½ | 34⅛ | 48⅞ | 45 | 46⅛ | 48¾ | 48⅛ |
| 1866 | 29⅛ | 50⅞ | 29¼ | 50⅞ | 45⅞ | 47½ | 43⅞ | 48⅝ |
| 1867 | 29¼ | 44¼ | 32⅞ | 45 | 38⅝ | 45½ | 38⅞ | 42⅝ |
| 1868 | 27 | 44 | 27½ | 45⅜ | 37 | 35¼ | 35⅛ | 36¼ |
| 1869 | 32⅛ | 48¼ | 33⅞ | 49⅞ | 42½ | 48¼ | 43⅝ | 52⅛ |
| 1870 | 29¼ | 46¼ | 32⅜ | 44½ | 41¼ | 41¾ | 38⅛ | 43¾ |
| 1871 | 39⅛ | 46½ | 30⅛ | 46 | 44 | 41¾ | 45⅝ | 47½ |
| 1872 | 26¾ | 38⅝ | 29¼ | 32 | 30⅛ | 33¼ | 27¾ | 39⅛ |
| 1873 | 37⅛ | 49 | 33½ | 46¾ | 45⅞ | 48¾ | 44¾ | 46½ |
| 1874 | 30⅛ | 53¾ | 32 | 51⅜ | 47½ | 49⅝ | 45¾ | 49¼ |
| 1875 | 29¼ | 38¾ | 27¾ | 42⅝ | 38¼ | 42⅝ | 33⅝ | 44¼ |
| 1876 | 19½ | 31⅝ | 22¾ | 36⅜ | 36⅜ | 34½ | 31 | 35 |
| 1877 | 37½ | 46¾ | 38½ | 49½ | 44½ | 42¾ | 48⅛ | 47½ |
| 1878 | 15⅞ | 33½ | 20¼ | 31½ | 27¾ | 32 | 29¼ | 32½ |
| 1879 | 13⅜ | 26⅜ | 16⅝ | 25½ | 27¼ | 28½ | 26⅝ | 31⅛ |
| 1880 | 38¼ | 57¼ | 41⅜ | 59⅜ | 50¼ | 55⅞ | 51¾ | 54⅞ |
| 1881 | 34¾ | 43½ | 36½ | 47¼ | 41½ | 47⅞ | 40½ | 45 |
| 1882 | 34⅛ | 46¼ | 36⅛ | 50⅞ | 44¾ | 48¼ | 44¾ | 46⅝ |
| 1883 | 43⅞ | 53¼ | 44¼ | 54⅛ | 46 | 49 | 44¼ | 48¾ |
| 1884 | 34½ | 43¾ | 33½ | 45¼ | 40 | 43¼ | 38¼ | 40¾ |
| 1885 | 17½ | 38½ | 21½ | 31½ | 28⅜ | 34 | 28⅞ | 32⅜ |
| 1886 | 27⅛ | 40¾ | 26 | 36½ | 29½ | 31⅛ | 26½ | 28⅜ |
| 1887 | 19½ | 27 | 21⅛ | 25½ | 21 | 22⅞ | 19 | 21 |
| 1888 | 22¾ | 40 | 25¾ | 36½ | 36¾ | 39 | 34 | 38 |
| 1889 | 25¼ | 41½ | 24½ | 36 | 30⅞ | 33⅞ | 28½ | 30¼ |
| 1890 | 29½ | 47½ | 28 | 43¾ | 36 | 37¼ | 31½ | 33½ |
| 1891 | 30⅞ | 49¼ | 30¾ | 43¼ | 41 | 44⅞ | 42⅛ | 40¾ |
| 1892 | 38⅝ | 51⅝ | 30¼ | 48⅜ | 41½ | 46¾ | 40⅝ | 40¼ |
| 1893 | 14½ | 31¼ | 17⅞ | 29½ | 28¼ | 30¾ | 28½ | 31⅝ |
| 1894 | 14¾ | 41 | 19 | 45 | 35⅞ | 36¾ | 32 | 37⅝ |
| **AVERAGES.** | | | | | | | | |
| 8 years, 1852-59 | 42⅛ | 48¾ | 39¾ | 49⅝ | 47¾ | 48 | 44⅛ | 47⅞ |
| 8 years, 1860-67 | 34⅜ | 51¼ | 37⅜ | 51⅛ | 44⅞ | 48 | 44¼ | 48⅜ |
| 8 years, 1868-75 | 31⅜ | 45⅝ | 31⅝ | 44⅞ | 40⅞ | 42⅝ | 39¼ | 44⅛ |
| 8 years, 1876-83 | 29⅝ | 42¼ | 32 | 44⅜ | 39¾ | 42⅜ | 39 | 42⅝ |
| 8 years, 1884-91 | 25⅞ | 41⅛ | 26⅜ | 37¼ | 33 | 35¾ | 31 | 33⅛ |
| 20 years, 1852-71 | 37 | 49¼ | 37⅜ | 49¾ | 45¼ | 46¾ | 43⅝ | 47⅜ |
| 20 years, 1872-91 | 28⅜ | 42¼ | 29½ | 41¼ | 37⅛ | 40 | 35⅝ | 39 |
| 40 years, 1852-91 | 32¾ | 45¾ | 33½ | 45½ | 41¼ | 43⅜ | 39½ | 43¼ |
| Last 20 years, per cent + or − first 20 years | −23.3 | −14.2 | −21.1 | −17.1 | −18.0 | −14 4 | −18.3 | −17·7 |

[1] 6 years, 1852-57, amm. salts, 400 lb.; 10 years, 1858-67, 200 lb.; 1868 and since, 275 lb. sodium nitrate.
[2] 6 years, 1852-57, rape-cake, 2000 lb., afterwards only 1000 lb., per acre per annum.

manures, of various nitrogenous manures, and of combinations of the two.

*Plan of experiments.*

Results are given for sixteen plots, arranged in four series of four plots each, and for each plot the produce—dressed grain per acre—is given for forty-three years in succession.

Series 1 comprises four plots, without any nitrogenous manure, namely—

Plot 1. Without manure.
" 2. Superphosphate alone.
" 3. Potassium, sodium, and magnesium sulphates.
" 4. Superphosphate, and potassium, sodium, and magnesium sulphates.

Series 2 comprises four plots, with the same four conditions as to mineral manures as to Series 1, with ammonium-salts, supplying 43 lb. of nitrogen per acre per annum, in addition, in each case.

Series 3, the same four conditions as to mineral manure; with, in each case, for six years 86 lb., and for ten years 43 lb., of nitrogen per acre per annum, as ammonium-salts, and for the last twenty-seven years 43 lb. as sodium nitrate.

Series 4, the same four conditions as to mineral manure; with, in each case, 2000 lb. rape-cake per acre per annum in the first six years, and 1000 lb. each year since.

*Nitrogen supplied.*

It may be mentioned that 1000 lb. rape-cake will, on the average, contain 48 to 50 lb. of nitrogen, or rather more than in the amounts of ammonium-salts or nitrate used, though probably not more is rendered available within the years of application; but there will obviously be accumulation, and some cumulative action, from year to year.

*Influence of seasons.*

Space will not allow us to call attention in any detail to the produce of individual years, but it will be observed that under all conditions of manuring, whether without nitrogenous supply as in Series 1, or with it, in the different forms and combinations, as in the other series, there is great fluctuation from year to year according to season. Thus, without manure, the produce ranges from 35 bushels in 1854 to only 6¼ bushels in 1879; with a full mineral manure (Series 1, plot 4) from 42 bushels in 1854 to 7¼ bushels in 1879; with the full mineral manure and ammonium-salts (Series 2, plot 4) = 43 lb. nitrogen, from 60⅝ bushels in 1854 to 22⅝ in 1887.

As in the cases of Series 3 and 4 more nitrogen was applied during the first six years than afterwards, the comparison of the produce in individual years at the beginning and at the end of the period have not quite equal significance; but it may be observed that, with the full mineral manure and ammonium-salts at first, and sodium nitrate afterwards (Series 3, plot 4), the produce varied from nearly 65 bushels in 1857 to 25½ bushels in 1879 and 1887; and lastly, with the full mineral

manure and rape-cake (Series 4, plot 4), it ranged from $62\frac{1}{4}$ bushels in 1857 to 21 bushels in 1887.

Looking to the average produce of each of the five eight-yearly periods, it is seen that, under all conditions of manuring, even in the case of the rape-cake with its annual accumulation, there is a general tendency to reduction in produce from the first and second periods to the third and fourth, and still more in the fifth period compared with the third and fourth. Then, again, the average produce is in every case lower over the second than over the first twenty years. But examination of the details shows that there was, nevertheless, frequently more than average produce in individual years during the latter half of the whole period. There was, in fact, great fluctuation due to season; but there is also evidence of reduction due to exhaustion in some cases. *Gradual reduction in produce.*

The bottom line of the tables, which shows the percentage reduction in the amount of produce over the second twenty years compared with the first twenty, enables us to discriminate in some degree between the effects of exhaustion and those of season. *Effects of exhaustion and season.*

It is seen that the four plots of Series 1 show a reduction over the second twenty years of from about 30 to 40 per cent, or about twice as much as in the case of either of the other series. There is here evidence that in the case of Series 1, without nitrogenous manure, much of the reduction over the second half of the period was due to nitrogen exhaustion. *Nitrogen exhaustion.*

In Series 2, with ammonium-salts, there is about 21 per cent reduction on plot 1, where the ammonium-salts are used alone, nearly as much on plots 2 and 3 with defective mineral manuring, and only about 12 per cent where full mineral manures are used in addition. *Effect of mineral manures.*

In Series 3, with sodium nitrate, there is a reduction of about 23 per cent where the nitrate is used without mineral manure, of 21 per cent where it is used with potash, soda, and magnesia, but without phosphate (plot 3), and of only 14 to 17 per cent where phosphates were used in addition to the nitrate.

Lastly, in Series 4, with rape-cake, which contains a considerable amount of mineral matter, there is a reduction of about 18 per cent on plots 1, 3, and 4, but of only about 14 per cent on plot 2 with superphosphate only as the mineral manure.

As already intimated, that there should be any reduction in the yield over the second half of the period where rape-cake with its annual residue and accumulation is used, is evidence that part of the reduction is due to an average of less favourable seasons over the later period. But that there *Influence of season, nitrogen exhaustion and phosphoric acid exhaustion.*

should be the greatest reduction in Series 1, where no nitrogen is supplied, is evidence of nitrogen exhaustion under those conditions; and that, within Series 2 and 3 respectively, there should be the greatest reduction where the ammonium-salts or nitrate is used without phosphates is evidence of phosphoric acid exhaustion in those cases.

*General view.* Leaving the results relating to the produce of each individual year, or of limited series of years, as given in Tables 22 and 23, a general view of the effects of the sixteen different conditions as to manuring is conveniently obtained in the summary Table 24. There is there given the average produce over the forty years on each of the sixteen

TABLE 24.—SUMMARY SHOWING THE AVERAGE PRODUCE OF BARLEY PER ACRE PER ANNUM, OVER FORTY YEARS, BY DIFFERENT MANURES.

| Plot. | | No nitrogenous manure | 200 lb ammon.-salts = 43 lb. nitrogen | 275 lb. sodium nitrate[1] = 43 lb. nitrogen. | 1000 lb. rape-cake[2] = 49 lb. nitrogen |
|---|---|---|---|---|---|
| | DRESSED GRAIN PER ACRE, BUSHELS. | | | | |
| 1 | Without mineral manure | 16½ | 29 | 32¼ | 41¼ |
| 2 | Superphosphate | 21¼ | 42¾ | 45¼ | 43⅝ |
| 3 | Potassium, sodium, and magnesium sulphates | 18 | 31⅝ | 33½ | 39½ |
| 4 | Superphospate, and potassium, sodium, and magnesium sulphates | 22⅝ | 43½ | 45½ | 43¼ |
| | STRAW PER ACRE, LB. | | | | |
| 1 | Without mineral manure | 1044 | 1793 | 2127 | 2624 |
| 2 | Superphosphate | 1210 | 2674 | 3018 | 2792 |
| 3 | Potassium, sodium, and magnesium sulphates | 1076 | 2011 | 2322 | 2627 |
| 4 | Superphosphate, and potassium, sodium, and magnesium sulphates | 1279 | 2904 | 3186 | 2875 |
| | TOTAL PRODUCE (GRAIN AND STRAW) PER ACRE, LB. | | | | |
| 1 | Without mineral manure | 1976 | 3420 | 3964 | 4953 |
| 2 | Superphosphate | 2422 | 5080 | 5596 | 5251 |
| 3 | Potassium, sodium, and magnesium sulphates | 2079 | 3773 | 4208 | 4876 |
| 4 | Superphosphate, and potassium, sodium, and magnesium sulphates | 2530 | 5365 | 5761 | 5319 |

[1] Ammonium-salts = 86 lb. nitrogen first 6 years, = 43 lb. next 10 years; sodium nitrate = 43 lb. nitrogen each year since.

[2] 2000 lb. rape-cake first 6 years, 1000 lb. since.

plots. The first column gives the results for the four plots of Series 1, without nitrogenous manure; the second column those for Series 2, with ammonium-salts equal to 43 lb. nitrogen per acre per annum; the third those for Series 3, first with ammonium-salts and afterwards sodium nitrate; and the fourth those for Series 4, with rape-cake. The upper division of the table gives, for each plot, the average produce of grain per acre in bushels; the middle division the average produce of straw in lb.; and the lower division the average total produce (grain and straw together) in lb.

*Phosphates and alkalies without nitrogen.*

Referring first to the results on the four plots without nitrogenous manure, as given in the first column of the table, it is seen that plot 2 with superphosphate, and plot 4 with superphosphate, and potassium, sodium, and magnesium sulphates, give considerably more produce than plot 3 with the potash, soda, and magnesia, without phosphate. There is more of straw as well as grain, and of course, therefore, of total produce, with than without the phosphate. There is, indeed, very marked effect by phosphatic manure, and very little by the alkalies.

*With nitrogen.*

The second column, with the same four conditions as to mineral supply, but with, in each case, 43 lb. of nitrogen per acre per annum as ammonium-salts, shows a very great increase. Even with the ammonium-salts alone there is a great increase; there is somewhat more on plot 3, where the alkalies are also applied, but very much more still on plot 2, where superphosphate, and on plot 4, where alkalies and superphoshate, are also used.

*Greatest increase from nitrogen and superphosphate.*

The third column shows that, with a larger amount of nitrogen supplied in the first six years, and with sodium nitrate instead of ammonium-salts in the later years, there is still greater increase; and again, the increase is by far the greater where the superphosphate is used.

*Rape-cake and other manures.*

The four plots of Series 4, with the rape-cake, show a much greater uniformity of result with the different mineral manures. Still, the two phosphate plots (2 and 4) give more produce than the two without phosphate. Referring to the produce of grain in illustration, it is seen that plots 1 and 3 with rape-cake without superphosphate, give considerably more produce than the same plots (1 and 3) in either Series 2 with the ammonium-salts, or in Series 3 with sodium nitrate. The explanation of this is that the rape-cake itself contains phosphates. On plots 2 and 4, on the other hand, where phosphates are added, there is about as much produce in Series 2 with the ammonium-salts, and more in Series 3 with the nitrate, than in Series 4 with the rape-cake.

Thus, then, whilst there is evidence that the phosphate of the rape-cake was effective when none was otherwise supplied,

when it was so applied in addition, there was more effect with the nitrate, with its more rapidly available nitrogen, than with the rape-cake with its greater actual amount of nitrogen, but in a less rapidly available condition.

*Nitrogen rapidly and slowly available.*

*Potash manures.*

Comparing the produce of plot 2 with superphosphate without potash, with that of plot 4 with superphosphate and potassium, sodium, and magnesium sulphates in addition, it is remarkable that, both in Series 2 with the ammonium-salts, and in Series 3 with nitrate of soda, there is, over the whole period of forty years, almost identically the same amount of barley grain without as with the potash. There is, however, rather more straw, and total produce, with than without the potash. Thus we have, with the ammonium-salts an average of 42¾ bushels without potash, and 43½ bushels with potash; and with the nitrate of soda 45¾ bushels without, and 45½ bushels with potash. Of straw, however, there is with the ammonium-salts an average of 2674 lb. without, and 2904 lb. with the potash; and on the nitrate plots 3018 lb. without, and 3186 lb. with potash.

*Potash of the soil.*

It will afterwards be seen that where nitrogen and phosphoric acid were liberally supplied without potash, the available potash of the soil itself became deficient; though this deficiency was to the last comparatively little manifested in the produce of grain. It is obvious, however, that with gradual reduction in the amount of total plant, the yield of grain must also in time materially diminish.

So much for the influence on the barley crop of different conditions of manuring, each continued for more than forty years, on the same plot, and in a field of somewhat heavy loam, with a raw clay subsoil, and chalk below giving good natural drainage.

*General results with artificial manures.*

It is seen that nitrogenous manures alone had much more effect than mineral manures alone. It was obvious, therefore, that the exhaustion induced by the continuous growth of the crop was characteristically that of nitrogen.

Both with and without nitrogenous supply, phosphates were more effective than potash salts, showing that the available store of phosphoric acid in the soil became deficient sooner than that of potash. With the shorter period of growth of barley than of wheat, and its greater proportion of surface-rooting, both nitrogenous and mineral exhaustion are sooner developed; and so far as mineral exhaustion is concerned, the available supply of phosphoric acid was sooner exhausted than was that of potash. Indeed, in ordinary agricultural practice, it is clearly established that superphosphate is more effective with the spring-sown than with the autumn-sown cereals.

*Superphosphate for spring-sown crops.*

*Influence of Season on the Amounts of Produce.*

It has been seen that there were, under all conditions of manuring, very great variations in the amount of produce from year to year, according to season. The extent and character of the influence of season will be brought prominently to view by comparing the produce of the best and the worst seasons of the forty, and comparing the characters of the seasons themselves. *Variations of produce with good and bad seasons.*

Tables 25 and 26 illustrate these points. Table 25 (p. 82) gives the produce of grain, the weight per bushel of the grain, the produce of straw, and the total produce (grain and straw together), of six very different conditions as to manuring in each of the best two seasons, and in the worst season of the whole series. There is also given the deficiency of produce in the bad season compared with that in each of the two good seasons.

For wheat, 1863 was the best season of the forty. For barley, 1863 was also a very good year for both grain and straw; but it was not so good for such a variety of manures as were 1854 and 1857, which (in the table) are adopted as the best seasons.

For almost all conditions of manuring, 1854 was the season of the highest total produce, grain and straw together; that is, it was the season of the greatest luxuriance or vegetative activity. But 1857 was, especially for the highest manuring, the one of the highest produce of grain, and of the highest quality or maturity of grain, as evidenced by the weight per bushel. Thus, 1854 was the highest for luxuriance, and 1857 the highest for maturation, of the crop. *Best seasons.*

For wheat, 1879 was decidedly the worst season of the forty. For barley also 1879 was a very bad season; but 1887 was worse still, especially for high manuring, and it is therefore adopted as the worst season for barley. *Worst seasons.*

The plots selected for illustration are those without manure, with farmyard manure, with mixed mineral manure alone, with mixed mineral manure and ammonium-salts, with mixed mineral manure and nitrate of soda, and with mixed mineral manure and rape-cake.

The figures speak for themselves, and will repay careful study; but we can only refer to them very briefly here. The lower division of the table shows that, under each of the six very different conditions as to manuring, 1854 yielded a much higher total produce (grain and straw together) than 1857. But the upper division shows that, notwithstanding there was the less amount of plant in 1857, as shown by the less amount of straw and total produce, it gave, in most cases, nearly as

much grain as 1854; and in two—those with the highest nitrogenous manuring (and both years were within the first six when the larger amounts were applied), 1857 gave more grain than 1854. The weight per bushel of the grain was also higher in 1857 on all the plots where nitrogenous manures were used.

TABLE 25.—PRODUCE OF BARLEY IN THE TWO BEST SEASONS, 1854 AND 1857; IN THE WORST SEASON, 1887; AND THE AVERAGE OVER FORTY YEARS, 1852-1891.

| Plots. | Descriptions of manures; quantities per acre. | Best seasons. 1854. | Best seasons. 1857. | Worst season, 1887. | 1887 + or −. 1854. | 1887 + or −. 1857. | Average of 40 years. |
|---|---|---|---|---|---|---|---|
| | **DRESSED GRAIN PER ACRE, BUSHELS.** | | | | | | |
| 1o | Unmanured . . . . . . . . . . | 35 | 26⅛ | 7½ | −27½ | −18⅝ | 10½ |
| 7–2 | Farmyard manure . . . . . . . | 56⅜ | 51¼ | 26 | −30⅜ | −25¼ | 48⅜ |
| 4o | Mixed mineral manure alone . . . . . | 42 | 39⅞ | 8⅝ | −33⅜ | −31¼ | 22⅛ |
| 4a | Mix. min. man. and 200 lb. am.-salts=43 lb. N. | 60⅝ | 57⅜ | 22⅝ | −38 | −34¾ | 43½ |
| 4aa | Do. and 275 lb. sodium nitrate=43 lb. N. . . . . . . | 62¾ | 64⅞ | 25½ | −37¼ | −39⅜ | 45½ |
| 4c | Do. and 1000 lb. rape-cake=49 lb. N. . . . . . . | 60¼ | 62¼ | 21 | −39¼ | −41¼ | 43¼ |
| | **WEIGHT PER BUSHEL OF DRESSED GRAIN, LB.** | | | | | | |
| 1o | Unmanured . . . . . | 53.6 | 52.0 | 51.0 | −2.6 | −1.0 | 52.0 |
| 7–2 | Farmyard manure . . . . . . . | 53.9 | 54.2 | 55.3 | +1.4 | +1.1 | 54.3 |
| 4o | Mixed mineral manure alone . . . . . | 54.0 | 53.7 | 51.8 | −2.2 | −1.9 | 53.0 |
| 4a | Mix. min. man. and 200 lb. am.-salts=43 lb. N. | 54.3 | 54.8 | 53.3 | −1.0 | −1.5 | 54.1 |
| 4aa | Do. and 275 lb. sodium nitrate=43 lb. N. . . . . . . | 52.1 | 53.9 | 53.7 | +1.6 | −0.2 | 53.7 |
| 4c | Do. and 1000 lb. rape-cake=49 lb. N. . . . . . . | 52.8 | 54.1 | 53.4 | +0.6 | −0.7 | 53.9 |
| | **STRAW PER ACRE, LB.** | | | | | | |
| 1o | Unmanured . . . . . . . . . . | 2442 | 1425 | 648 | −1794 | −777 | 1044 |
| 7–2 | Farmyard manure . . . . . . . | 4171 | 2649 | 1842 | −2329 | −807 | 3247 |
| 4o | Mixed mineral manure alone . . . . . | 2595 | 1920 | 630 | −1965 | −1290 | 1279 |
| 4a | Mix. min. man. and 200 lb. am.-salts=43 lb. N. | 4530 | 3120 | 1705 | −2825 | −1415 | 2904 |
| 4aa | Do. and 275 lb. sodium nitrate=43 lb. N. . . . . . . | 5487 | 4057 | 2073 | −3414 | −1984 | 3186 |
| 4c | Do. and 1000 lb. rape-cake=49 lb. N. . . . . . . | 4712 | 3705 | 1740 | −2972 | −1965 | 2875 |
| | **TOTAL PRODUCE (GRAIN AND STRAW) PER ACRE, LB.** | | | | | | |
| 1o | Unmanured . . . . . . . . . . | 4405 | 2878 | 1043 | −3362 | −1835 | 1976 |
| 7–2 | Farmyard manure . . . . . . . | 7298 | 5564 | 3294 | −4004 | −2270 | 6015 |
| 4o | Mixed mineral manure alone . . . . . | 4969 | 4111 | 1088 | −3881 | −3023 | 2530 |
| 4a | Mix. min. man. and 200 lb. am.-salts=43 lb. N. | 7958 | 6336 | 2929 | −5029 | −3407 | 5365 |
| 4aa | Do. and 275 lb. sodium nitrate=43 lb. N. . . . . . . | 9026 | 7734 | 3455 | −5571 | −4279 | 5701 |
| 4c | Do. and 1000 lb. rape-cake=49 lb. N. . . . . . . | 8125 | 7241 | 2875 | −5250 | −4366 | 5319 |

*Note.*—Plot 4aa, ammonium-salts=86 lb. nitrogen first 6 years, =43 lb. next 10 years; sodium nitrate=43 lb. nitrogen last 24 years. Plot 4c, 2000 lb. rape-cake first 6 years 1000 lb. since.

The contrast between the produce in these two very different good years, and that in the worst season, 1887, is very striking; in fact, the difference amounted in several cases to more than the average crop of the country.

For comparison with the produce of these selected years, the average on each of the six plots over the forty years is given. It will be seen how very much higher than the average is the produce in the good years, and how very much lower it is in the bad season; indeed it is, in the bad season, generally only about, or less than, half as much as the average.

It will be of interest to consider, however briefly, some of the climatic characteristics of these various seasons.

*Temperature and rainfall.*

The next Table (26) shows, for each month, of each of the three seasons, reckoning from October in the preceding year to September in the year of growth, the mean temperature, and the rainfall, above or below the average.

TABLE 26.—Character of the two best Seasons, 1854 and 1857, and of the worst Season, 1887. Temperature and Rainfall + or – Average.

| | Mean temperature. | | | Rainfall. | | | Days of rain, 0.01 inch or more. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Best two. | | Worst. | Best two. | | Worst. | Best two. | | Worst. |
| | 1853-4. | 1856-7. | 1886-7. | 1853-4. | 1856-7. | 1886-7. | 1853-4. | 1856-7. | 1886-7. |
| | Deg. F. | Deg. F. | Deg. F. | Inches. | Inches. | Inches. | Days. | Days. | Days. |
| October . . | +1.3 | +2.1 | +3.7 | +1.43 | −0.89 | −1.39 | +13 | − 4 | 0 |
| November . | −0.2 | −1.6 | +1.7 | −0.45 | −1.15 | +0.62 | − 2 | − 3 | +2 |
| December . | −5 2 | +1.0 | −2.7 | −1.30 | −0.27 | +1.50 | 0 | + 1 | +6 |
| January . | +2.4 | 0.0 | −1.0 | −0.60 | +0.60 | −0.85 | + 3 | + 7 | +2 |
| February . | +0.8 | +0.5 | +0.2 | −0.29 | −1.30 | −0.97 | − 3 | − 8 | −7 |
| March . . | +2.7 | +0.7 | −3.5 | −1.28 | −0.77 | −0.25 | − 6 | − 2 | −2 |
| April . . | +2.3 | −0.4 | −2.0 | −1.11 | −0.30 | +0.05 | − 4 | + 7 | 0 |
| May . . . | −1.6 | +1.5 | −2.7 | +1.51 | −1.67 | −0.28 | + 5 | − 6 | +7 |
| June . . . | −2.3 | +3.8 | +2.7 | −0.99 | +0.80 | −0.67 | + 1 | − 2 | −8 |
| July . . . | −1.3 | +2.9 | +4.9 | −0.85 | −1.50 | −1.31 | + 4 | − 2 | −1 |
| August . . | 0.0 | +4.9 | +1.6 | +0.21 | +0.10 | −0.05 | + 1 | 0 | −2 |
| September . | +1.6 | +3.2 | −2.5 | −1.42 | +1.00 | −0.19 | − 3 | + 1 | +4 |
| Averages | | +1.5 | | | | | | | |
| Totals | | | | −5.14 | −5.35 | −3.79 | + 9 | −11 | +1 |

It is obvious that different seasons will differ almost infinitely at each succeeding period of their advance, and that with each variation the character of development of the plant will also vary, tending to luxuriance or to maturation—that is, to quantity, or to quality, as the case may be. Hence only a very detailed consideration of climatic statistics, taken together

with careful periodic observations in the field, can afford a really clear perception of the connection between the ever-fluctuating characters of season, and the equally fluctuating characters of growth and produce. It is, in fact, the distribution of the various elements making up the season, their mutual adaptations, and their adaptation to the stage of growth of the plant, which throughout influence the tendency to produce quantity or quality.

Still it will be seen that the limited summary of the meteorological conditions of the seasons in question, which can alone be given here, is not without significance.

*Characteristics of the good seasons.*

First, then, as to 1854, the season of great luxuriance and high total produce. The table shows that there was an excess of temperature in January, February, March, and April, with a deficiency of rain from November (1853) to April inclusive; but that during May, June, and July—that is, the months of active above-ground growth—there were lower than the average temperatures, with a considerable excess of rain in May, and then a deficiency—conditions obviously favouring continued vegetation and slow maturation.

For the crop of 1857, there was less excess of temperature, and less than the average amount of rain, to the end of April; then from May to August inclusive there was both considerable excess of temperature and considerable deficiency of rain—that is, there were throughout the period of active above-ground growth conditions favouring seeding tendency and maturation rather than luxuriance.

Thus, then, the two good seasons were very different in their climatic characteristics, as they were in the character of their produce.

*Characteristics of the bad seasons.*

Compared with these, it may be mentioned that the very bad season of 1879 was characterised by much lower than average temperatures throughout the winter, spring, and summer, with at the same time great excess of rain from January to September inclusive; the result being amounts of produce greatly below the average, and very low weight per bushel of the grain. The season of 1887, on the other hand, which gave even lower amounts of produce than 1879, especially with high manuring, and which is adopted as the "worst" season, was in some important respects very different in character. Thus, whilst the crop of 1879 failed from low temperatures, combined with excess of rain throughout, the season of 1887 was characterised by low temperatures, especially in March, April, and May, but associated with a deficiency of rain commencing in January. The result was very restricted spring growth. In June and July, however, the temperature was considerably in excess of the average, but

with continued and considerable deficiency of rain, the combination further restricting growth, and bringing on premature ripening.

*Influence of Exhaustion, Manures, and Variations of Season, on the Composition of the Barley Crops.*

In the case of wheat it was found that the supplies within the soil—both of nitrogen and of mineral constituents—had a very direct influence on the composition of the crop so long as it was only in the vegetative stage; but that there was, nevertheless, very great uniformity in the composition of the final product of the plant—the seed—provided only that it was perfectly matured. The composition of the straw, however, showed a very direct connection with the supplies by the soil. The composition of the grain was, on the other hand, materially influenced by variations of *season*. But variations of season obviously have great influence on the condition of maturation; whilst difference in maturation implies difference in organic composition—the amount of carbohydrates (starch especially) formed. In fact, such variations in composition imply deviations from perfect and normal maturation; and such deviations are associated not only with differences in the organic composition—the relation of the nitrogenous to the non-nitrogenous constituents—but with differences in the mineral composition also. *Composition of the crop as influenced by exhaustion, manures, and season.*

It follows that variations in the composition of the final and very definite product—the seed—should be much more clearly traceable to variations of season than to variations in the supplies within the soil—that is, than to exhaustion or manures. This was found to be very strikingly so in the case of *wheat*, and we have now to consider how far it is so with its near ally—*barley*.

The results given in Table 27 (p. 86) forcibly illustrate the much greater influence of variations of season than of manures on the composition of barley grain. Many complete analyses of the ash of the grain (and also the straw), grown by different manures, and in different seasons, have been made; and taking for illustration the important and characteristic constituents, potash and phosphoric acid, the table shows, for three very different manurial conditions, the highest, the lowest, and the mean amounts, of potash and phosphoric acid, in 1000 parts of the dry substance of the grain, and of the straw, in different seasons. The manurial conditions selected are—1, without manure; 2, with farmyard manure; 3, mixed mineral manure (including potash) and ammonium-salts. *Table 27 explained.*

First as to the amounts of potash in 1000 parts dry sub-

stance of the grain of the differently manured plots, in the different seasons. It is seen that there is much greater variation in the proportion of the potash in the different seasons with the same manure, than there is with the different manures. Further, the seasons showing the highest amount of potash were of much higher maturing character than those showing the lowest amounts.

*Potash in the crop as influenced by season and manures.*

TABLE 27.—HIGHEST, LOWEST, AND MEAN AMOUNTS, OF POTASH AND PHOSPHORIC ACID, PER 1000 DRY SUBSTANCE.

| | | Per 1000 dry grain. | | | | | Per 1000 dry straw. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Highest. | | Lowest. | | Mean | Highest. | | Lowest. | | Mean. |
| | | **POTASH.** | | | | | | | | | |
| 1*o* | Unmanured | 1871 | 7.66 | 1853 | 6.00 | 6.54 | 1871 | 11.77 | 1856 | 5.25 | 8.55 |
| 7-2 | Farmyard man. | 1871 | 8.36 | 1856 | 5.89 | 6.81 | 1871 | 22.01 | 1856 | 6.76 | 13.23 |
| 4*a* | Mix. min. man. and amm.-salts | 1871 | 7.98 | 1852 | 5.62 | 6.61 | 1871 | 22.53 | 1852 | 5.67 | 14.05 |
| | | **PHOSPHORIC ACID.** | | | | | | | | | |
| 1*o* | Unmanured | 1852 | 10.08 | 1854 | 8.85 | 9.27 | 1856 | 2.60 | 1863 | 1.20 | 1.74 |
| 7-2 | Farmyard man. | 1871 | 10.50 | 1854 | 9.23 | 9.99 | 1856 | 2.92 | 1863 | 1.48 | 2·19 |
| 4*a* | Mix. min. man. and amm.-salts | 1856 | 10.39 | 1863 | 8.84 | 9.58 | 1856 | 3.12 | 1863 | 1.06 | 1.94 |

Next it is seen that there is still greater, indeed enormous, variation in the amount of potash in the dry substance of the straw, with the same manure, in different seasons. There is also great variation according to manure; comparatively little when there was full supply, but considerable without manure—that is, with exhaustion.

*Phosphoric acid in the crop as influenced by season and manure.*

Turning now to the phosphoric acid in the grain, there is here again much more variation in different seasons with the same manure than with the different manures. But whilst in the case of potash there is the higher proportion in the *better* seasons, in that of phosphoric acid there are lower amounts in the dry substance in the *better* seasons. In fact, high amount of potash in the ash, and in the dry substance of the grain, is, as a rule, associated with high maturation—that is, with high proportion of starch; whilst high proportion of phosphoric acid is generally associated with low maturation, and with high proportion of nitrogen.

The proportion of phosphoric acid in the straw also varies more with season than with manure, and it is the highest in the worst seasons.

The connection between maturation and composition is further illustrated by the results in Table 28, which shows the general characters of the produce, as indicated by the weight per bushel of the grain, of four very different seasons so far as the maturation of the grain was concerned. The table further shows—the percentage of ash (pure) in the dry matter of the grain, and of the straw; the percentage of potash and of phosphoric acid in the ash of the grain, and of the straw; also the potash and phosphoric acid per 1000 dry matter of grain, and of straw—the results being the means of six differently manured plots in each season. Lastly, the seasons are arranged in the order of highest weight per bushel of grain, this being, upon the whole, the best practical measure of high quality, or at least of high maturation. *Maturation and composition.*

TABLE 28.

| Harvests. | Weight per bushel of grain. lb. | Per cent ash (pure) in dry matter. | Per cent in ash (pure). | | Per 1000 dry matter. | |
|---|---|---|---|---|---|---|
| | | | Potash. | Phosphoric acid. | Potash. | Phosphoric acid. |
| GRAIN. | | | | | | |
| 1871 | 55.9 | 2.65 | 29.80 | 35.33 | 7.89 | 9.39 |
| 1863 | 55.3 | 2.55 | 26.59 | 35.80 | 6.78 | 9.15 |
| 1852 | 51.7 | 2.48 | 23.84 | 40.89 | 5.90 | 10.13 |
| 1856 | 47.4 | 2.44 | 24.21 | 41.35 | 5.89 | 10.09 |
| STRAW. | | | | | | |
| 1871 | 55.9 | 6.27 | 26.01 | 3.68 | 16.57 | 2.31 |
| 1863 | 55.3 | 5.48 | 24.91 | 2.29 | 13.99 | 1.26 |
| 1852 | 51.7 | 4.45 | 14.62 | 4.05 | 6.58 | 1.81 |
| 1856 | 47.4 | 4.49 | 13.51 | 6.42 | 6.10 | 2.89 |

It will be seen that the average weight per bushel of the grain was in 1871, 55.9 lb.; in 1863, 55.3 lb.; in 1852, 51.7 lb.; and in 1856 only 47.4 lb.; or about 8 lb. less than in the two seasons of highest weight. There is here, then, very great variation in the character of these four seasons, and in the degree of maturation of the grain accordingly. *Season and weight of grain.*

No determinations of nitrogen are available; but it may be stated that the percentage of nitrogen is almost uniformly lower in the seasons of high maturation. Turning to the particulars of composition given in the table for each of the four seasons, it is seen that, in both grain and straw, there is a higher percentage of ash in the dry substance the higher the quality of the grain. There are also higher percentages *Nitrogen and quality of grain.*

*Potash, phosphoric acid, and quality of grain.*

of potash, but lower percentages of phosphoric acid, both in the ash and in the dry substance, the higher the quality of the grain.

In wheat, however, there is lower not higher percentage of ash in the dry substance of the grain the higher its quality. But in wheat, as in barley, there is higher percentage of potash, and lower percentage of phosphoric acid, in the ash, the higher the quality. On the other hand, there is not in the case of wheat, as there is in that of barley, a much higher percentage of potash in the dry substance the higher the quality. This difference may be partly due to the larger proportion of starch to nitrogenous substance in the barley; but it is probably in part also due to the *paleæ* (or chaff) of the barley, but not of the wheat, being adherent, and retaining the surplus potash brought up for grain-formation.

In both descriptions of grain there is very uniformly a lower proportion of phosphoric acid in the dry matter the higher the quality of the grain.

In the straw there is high percentage of ash in the dry matter, high percentage of potash, and low percentage of phosphoric acid, in the ash, and in the dry matter, the higher the quality of the grain. In the straw, however, the variations show a much wider range, indicating much less definiteness, and greater irregularity in condition.

*Recapitulation.*

Thus, then, the higher the quality of the barley-grain—that is, the higher its proportion of starch—the higher is the proportion of potash and the lower is that of phosphoric acid. Though not shown in the table, it may be mentioned that with a higher proportion of potash there is generally a lower proportion of both lime and magnesia, and with a lower proportion of phosphoric acid there is a somewhat higher proportion of sulphuric acid.

*Good seasons and soda in crop.*

Another point of interest is, although it is true the amounts are small, that there is a tendency to a higher proportion of soda in the grain-ash, and in the dry matter of the grain, in the better seasons, even when there is no deficiency of potash. This, again, is probably due to the ash of the barley-grain containing that of the adherent *paleæ*.

*Silica in straw.*

In relation to the composition of the straw, the most striking result is (though not shown in the table) that there is little more than two-thirds as high a percentage of silica in the ash of the produce of the better as in that of the worse seasons.

*Mineral manures and mineral composition of crop.*

The results in the next Table (29) illustrate the influence of *exhaustion* and of *full supply*, of mineral or ash constituents, on the mineral composition of the produce, both grain and straw.

TABLE 29.—EXPERIMENTS ON BARLEY. Potash, Soda, Phosphoric Acid, and Silica, per cent in ash, per 1000 dry substance, and quantities per acre.

| | Per cent in ash. | | | | Per 1000 dry matter. | | | | Per acre per annum, lb. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain. | | Straw. | | Grain. | | Straw. | | In grain. | | In straw. | | In total produce. | |
| | AMMONIUM-SALTS=43 LB. NITROGEN AND SUPERPHOSPHATE. | | | | | | | | | | | | | |
| | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash |
| | 2a. | 4a. | 2a. | 4a. | 2a. | 4a. | 2a. | 4a. | 2a. | 4a. | 2a. | 4a. | 2a. | 4a. |
| **POTASH.** | | | | | | | | | | | | | | |
| | per cent. | per cent. | per cent | per cent | per cent. | per cent | per cent | per cent. | lb. | lb. | lb. | lb | lb. | lb. |
| 10 years, 1852-61 | 26.79 | 27.62 | 18.44 | 27.85 | 6.22 | 6.52 | 8.54 | 14.65 | 13.1 | 13.8 | 22.5 | 39.9 | 35.6 | 53.7 |
| " " 1862-71 | 25.97 | 28.46 | 13.31 | 32.92 | 6.23 | 6.82 | 6.41 | 18.51 | 14.5 | 15.3 | 16.4 | 48.4 | 30.9 | 63.7 |
| " " 1872-81 | 25.68 | 28.85 | 9.72 | 33.64 | 6.02 | 6.99 | 4.41 | 18.10 | 11.5 | 13.7 | 8.0 | 37.8 | 19.5 | 51.5 |
| " " 1882-91 | 25.35 | 28.67 | 7.36 | 29.72 | 5.85 | 6.90 | 3.38 | 15.25 | 9.7 | 12.8 | 6.0 | 32.0 | 15.7 | 44.8 |
| 40 " 1852-91 | 25.95 | 28.40 | 12.21 | 31.03 | 6.08 | 6.81 | 5.69 | 16.63 | 12.2 | 13.9 | 13.2 | 39.5 | 25.4 | 53.4 |
| **SODA.** | | | | | | | | | | | | | | |
| 10 years, 1852-61 | 1.15 | 0.51 | 6.42 | 2.50 | 0.27 | 0.12 | 2.07 | 1.32 | 0.6 | 0.2 | 7.8 | 3.6 | 8.4 | 3.8 |
| " " 1862-71 | 2.07 | 0.58 | 11.39 | 2.30 | 0.50 | 0.14 | 5.40 | 1.29 | 1.1 | 0.3 | 14.1 | 3.4 | 15.2 | 3.7 |
| " " 1872-81 | 2.83 | 0.77 | 12.69 | 2.09 | 0.66 | 0.18 | 5.75 | 1.13 | 1.3 | 0.4 | 10.5 | 2.3 | 11.8 | 2.7 |
| " " 1882-91 | 2.94 | 0.44 | 11.85 | 1.85 | 0.68 | 0.11 | 5.44 | 0.95 | 1.1 | 0.2 | 9.6 | 2.0 | 10.7 | 2.2 |
| 40 " 1852-91 | 2.25 | 0.58 | 10.59 | 2.10 | 0.53 | 0.14 | 4.91 | 1.17 | 1.0 | 0.3 | 10.5 | 2.8 | 11.5 | 3.1 |
| **PHOSPHORIC ACID.** | | | | | | | | | | | | | | |
| 10 years, 1852-61 | 38.55 | 38.53 | 3.06 | 2.97 | 8.95 | 9.10 | 1.42 | 1.56 | 18.8 | 19.2 | 3.7 | 4.3 | 22.5 | 23.5 |
| " " 1862-71 | 36.36 | 37.31 | 2.55 | 2.47 | 8.72 | 8.95 | 1.23 | 1.39 | 20.2 | 20.1 | 3.2 | 3.6 | 23.4 | 23.7 |
| " " 1872-81 | 37.65 | 38.36 | 3.33 | 2.91 | 8.82 | 9.29 | 1.51 | 1.57 | 16.9 | 18.1 | 2.8 | 3.3 | 19.7 | 21.4 |
| " 1882-91 | 38.25 | 39.56 | 3.76 | 3.30 | 8.82 | 9.52 | 1.73 | 1.60 | 14.7 | 17.7 | 3.1 | 3.6 | 17.8 | 21.3 |
| 40 " 1852-91 | 37.70 | 38.44 | 3.18 | 2.91 | 8.83 | 9.22 | 1.47 | 1.55 | 17.6 | 18.3 | 3.2 | 3.7 | 20.8 | 22.5 |
| **SILICA.** | | | | | | | | | | | | | | |
| 10 years, 1852-61 | 18.60 | 18.67 | 47.87 | 43.67 | 4.32 | 4.41 | 22.16 | 22.98 | 9.1 | 9.3 | 58.5 | 62.6 | 67.6 | 71.9 |
| " " 1862-71 | 20.62 | 19.18 | 43.39 | 35.41 | 4.95 | 4.60 | 20.92 | 19.91 | 11.5 | 10.3 | 53.6 | 52.1 | 65.1 | 62.4 |
| " " 1872-81 | 18.50 | 17.47 | 43.73 | 34.09 | 4.31 | 4.23 | 19.82 | 18.34 | 8.3 | 8.3 | 36.3 | 38.3 | 44.6 | 46.6 |
| " " 1882-91 | 18.36 | 16.73 | 46.00 | 37.16 | 4.24 | 4.03 | 21.16 | 19.06 | 7.1 | 7.5 | 37.5 | 40.0 | 44.6 | 47.5 |
| 40 " 1852-91 | 19.02 | 18.01 | 45.27 | 37.58 | 4.46 | 4.32 | 21.02 | 20.07 | 9.0 | 8.9 | 46.5 | 48.2 | 55.5 | 57.1 |

They relate to the mineral composition of the produce grown for forty years in succession:

1. By ammonium-salts and superphosphate.
2. By ammonium-salts, superphosphate, and potassium, sodium, and magnesium, salts, in addition.

There are given results obtained by complete analyses of the ash of samples mixed in proportion to the amount of the produce (grain and straw separately) each year—for the four ten-year periods, 1852-61, 1862-71, 1872-81, and 1882-91.

The upper division of the table gives for the potash, the second for the soda, the third for the phosphoric acid, and the fourth for the silica—

1. The percentage in the ash (pure) of the grain, and of the straw.
2. The amounts per 1000 dry matter of grain, and of straw.
3. The amounts per acre per annum, lb., in the grain, in the straw, and in the total produce (grain and straw together).

*Potash.* First referring to the potash: its percentage, even in the grain-ash, is seen somewhat to diminish from period to period where none was supplied in manure, and somewhat to increase where there was an annual supply of it by manure. In the straw-ash, however, the percentage of potash went down from 18.44 over the first period to only 7.36, or less than half, over the fourth, where none was supplied; but it increased from 27.85 per cent over the first, to 33.64 over the third, but to only 29.72 over the fourth period, where it was annually supplied. Thus the influence of exhaustion, or of full supply, of potash, has been comparatively small on the mineral composition of the grain, but very great on that of the straw.

The point is further illustrated in the next results, which show the amounts of potash per 1000 dry matter of grain and of straw respectively. There is, again, comparatively little variation in the relation of the potash to the organic matter in the case of the grain, but very great variation in that of the straw, accordingly as there is exhaustion or full supply. When it is borne in mind that the ash of barley-grain contains that of the adherent *paleæ* as well as that of the grain proper, the conclusion is that the variation in the proportion of potash to the fixed organic substance of the grain itself, is much less than the figures would indicate. It is probable that the variation, such as it is, is associated with a different relative proportion of the organic compounds themselves—of the fully-matured non-nitrogenous to the nitrogenous bodies. In fact, the evidence, duly considered,

is not in favour of the view that there is variation in the proportion of the potash to the fixed and ripened non-nitrogenous constituents, with the formation of which it is probably to a great extent associated.

*Amount of potash taken up per acre.* The effects of exhaustion, or of full supply, of constituents, are more strikingly still brought out by a study of the figures showing the amounts of potash taken up and retained per acre by the above-ground growth, without and with the supply of it. Thus the average amounts of potash per acre per annum, in the entire crop (grain and straw together) were, over the four successive periods without supply of it—35.6, 30.9, 19.5, and 15.7 lb.; and with full supply they were, over the same periods—53.7, 63.7, 51.5, and 44.8 lb. That is to say there was, without supply, less than half as much potash annually stored up in the crop over the last as over the first ten years of the forty. On the other hand, with full supply, there was over the second period more than, and over the third about the same amount as, over the first period, but there was less over the fourth. Further, there was, over the first period about one and a-half time, over the second more than twice, over the third more than two and a-half, and over the fourth nearly three times, as much potash in the total crop with as without supply. Lastly, over the forty years there was, without supply of potash an average of only 25.4 lb., but with it 53.4 lb. of potash per acre per annum in the crop.

*Potash accumulated in the grain.* Yet with these enormous differences in the amounts taken up and retained by the entire above-ground growth in the different cases, there was proportionally very much less difference in the amounts accumulated in the grain. Thus, over the first period, the amounts in the grain were, over the first period—without supply 13.1 lb., and with it 13.8 lb.; over the second—without supply 14.5 lb., and with it 15.3 lb.; over the third—without supply 11.5 lb., and with supply, 13.7 lb.; and over the fourth period—without supply 9.7 lb., and with supply 12.8 lb. Lastly, over the total period of forty years the amounts were—without supply 12.2 lb., and with supply 13.9 lb.

It is thus seen that over each period there was rather less in the grain without than with supply, but that the deficiency was not material until the third period—that is, until after twenty years without supply in the one case, and twenty years with it in the other.

*Amount of produce.* In reference to these results, it will be of interest to consider what were the actual amounts of produce—grain, straw, and total—on each of the two plots, over the successive

ten-yearly periods, and over the forty years. The following Table (30) gives particulars on these points:—

TABLE 30.

| | Dressed grain. | | Straw. | | Total produce. | |
|---|---|---|---|---|---|---|
| | Ammonium-salts=43 lb. nitrogen and superphosphate. | | | | | |
| | Without potash. | With potash. | Without potash. | With potash. | Without potash. | With potash. |
| | *2a* | *4a* | *2a* | *4a* | *2a* | *4a* |
| | bushels. | bushels. | cwt. | cwt. | lb. | lb. |
| 10 years, 1852-61 . . | 45⅝ | 46⅛ | 27⅞ | 28⅞ | 5683 | 5827 |
| 10 years, 1862-71 . . | 48⅜ | 46⅜ | 27½ | 28 | 5837 | 5808 |
| 10 years, 1872-81 . . | 40½ | 40¾ | 20½ | 23½ | 4584 | 4969 |
| 10 years, 1882-91 . . | 36⅝ | 40¾ | 19¾ | 23⅜ | 4218 | 4854 |
| 40 years, 1852-91 . . | 42¾ | 43½ | 23⅞ | 25⅞ | 5081 | 5364 |

*Potash and total produce.*

It will be seen that there was almost identically the same amount of produce of grain per acre per annum over the forty years without as with the supply of potash—the average annual deficiency being only ¾ bushel; and the details show that the falling off was chiefly during the fourth period of ten years. There was, however, some deficiency of straw without potash-supply over each of the four periods. It was considerable over the third and fourth periods, and it amounted to an average of 2 cwt. per acre per annum over the forty years.

*Potash in grain and straw.*

It would appear, therefore, that the diminished amount of potash taken up by the plant where it was not supplied was sufficient for the exigencies of grain-formation for the greater part of the whole period; and that at least a large proportion of the excess taken up where it was liberally supplied was surplusage so far as the requirements of the grain were concerned. Some idea of how great was the surplusage may be formed by reference to the difference in the amounts of potash eventually remaining in the straw. Thus the average amounts of potash per acre per annum in the straw were—over the first period, without supply 22.5 lb., and with it 39.9 lb., or + 17.4 lb.; over the second period, without supply 16.4 lb., and with it 48.4 lb., or + 32.0 lb.; over the third period, without supply 8.0 lb., and with it 37.8 lb., or + 29.8 lb.; over the fourth period, without supply 6 lb., and with it 32 lb., or + 26 lb.; and over the forty years, without supply 13.2 lb., and with it 39.5 lb., or 26.3 lb. per acre per annum more with than without supply. It is not to

be supposed, however, that the whole of these plus amounts were surplusage; for although the average yield of grain has been to such a great extent maintained, the character of the plant has obviously depreciated for a good many years, and several times in recent seasons even the yield of grain has been considerably deficient. Indeed it would seem that the plant has become more and more sensitive to adverse conditions of soil and season.

*Soda in the crop.*

Turning now to the *soda*, it is seen that, whether we look at its percentage in the ash of the grain and of the straw, its proportion in 1000 dry substance, or the amounts in the acreage crops, very much more was found in the crops grown without its supply, but where potash was deficient, than where soda was itself annually supplied. This is strikingly illustrated by reference to the average amounts per acre per annum in the total crops, grain and straw together. Thus the average amounts of soda in the total crop were—over the first period, without any supply of either potash, soda, or magnesia, 8.4 lb., and with the supply of all three, only 3.8 lb.; over the second period, without the supply 15.2 lb., and with it only 3.7 lb.; over the third period, without the supply 11.8 lb., and with it only 2.7 lb.; over the fourth period, without the supply 10.7 lb., and with it only 2.2 lb.; and lastly, over the forty years, without supply of either potash, soda, or magnesia, 11.5 lb. of soda, and with the supply of all three, only 3.1 lb. of soda per acre per annum.

Thus, then, not only was there much more soda taken up or retained by the plant where it was not supplied than where it was, but it is evident that there was the more soda taken up the less the supply of potash. The amounts of soda retained in the grain are, however, seen to be but small; there was more, it is true, where there was a deficiency of potash, and where more soda was taken up. But looking to the amounts of soda per cent in the grain-ash, or per 1000 dry substance of the grain, it would seem probable that the larger amounts where there was a deficiency of potash, and more total soda taken up, were only due to larger amounts eliminated from the grain proper, and retained in the adherent *paleæ*, or chaff. Whether, however, the soda has been of any avail in the earlier or merely vegetative stages of growth, as a carrier, or otherwise, may be a question.

*Phosphoric acid in the crop.*

Next as to the *phosphoric acid*, of which there was the same annual supply on both plots. It is seen that, whether we take its percentage in the ash, its proportion to the dry substance, or its average quantity per acre, the amounts are, in the comparable cases, comparatively uniform; the differences not being greater than can be supposed to be connected with

the differences in growth due to the differences in the supply of other constituents.

*Silica in the crop.* Lastly, as to *silica;* the chief point of interest to remark is that, as the figures show, its percentage in these barley-grain-ashes ranges from under 17 to more than 20, whereas in wheat-grain-ash it ranges only from about 0.5 to about 1.5 per cent; or, if we take the proportion of silica to 1000 dry substance of grain, in barley it ranges from 4 to 5 parts, and in wheat only from about 0.1 to about 0.3 parts. This difference is obviously due to the chaff being adherent in the case of barley and not in that of wheat; and the figures afford clear illustration of the material degree in which the composition of barley-grain-ash is influenced by the inclusion in it of what is, in a sense, extraneous matter. It is indeed obvious that under such circumstances we should expect, as we find, less definiteness in the mineral composition of the grain of barley than in that of wheat.

*Available mineral plant-food in the soil.* In reference to the foregoing results showing the influence of exhaustion and of supply, of certain mineral constituents within the soil on the mineral composition of the produce grown, it is obviously of interest to consider, as far as existing evidence will permit, the amount, and the condition of availability, especially of the potash and the phosphoric acid, within the soil. Unfortunately, results obtained by the generally adopted methods of soil-analysis do not enable us to discriminate between the total and the immediately or approximately available constituents. The difficulty was recognised and pointed out at Rothamsted very early in the course of our investigations. From time to time the subject has also been discussed by others; and in recent years several experimenters have approached it from various points of view, with the object of fixing upon some useful modification of method.

*Soil-analysis unreliable.*

*Liebig's analyses of Rothamsted soils.* More than twenty years ago, Hermann von Liebig having asked for samples of some of the plots of the Rothamsted experimental wheat-field, samples from five plots, to three depths of 9 inches each in each case, were supplied to him. He determined in them, besides other constituents, the potash and the phosphoric acid, the former in a dilute acetic acid extract, and the latter in a dilute nitric acid extract. The results unmistakably showed differences in the amounts of potash and phosphoric acid in the soils, according to the manures employed. They further brought out the interesting fact, that comparatively very little of the applied potash or phosphoric acid had gone below the first 9 inches of soil, and that certainly none had gone into the third depth.

In our own country, for some years past, Dr Bernard

Dyer has been investigating the subject of "*The analytical determination of probably available 'mineral' plant-food in soils*";[1] and, at the suggestion of Professor Armstrong, one of the Rothamsted Trust Committee, he asked whether we could supply him, for the purposes of his investigation, with samples of soils from some of the experimental fields at Rothamsted, of which the manure and crop history was known. Accordingly, in 1889, we gave him facilities for taking samples of the surface-soil, to a depth of 9 inches, from twenty-two of the plots in the experimental barley-field; and we also provided him with samples which had been collected in 1882, from a few selected plots, to the depth of three times 9 inches.

*Dyer's analyses of Rothamsted soils.*

In all these samples Dr Dyer has determined the total potash, by acid, fusion, &c.; the amount dissolved by hydrochloric acid, and the amount taken up by a 1-per-cent citric acid solution; also the amounts of phosphoric acid, by hydrochloric acid, and by a 1-per-cent solution of citric acid. Dr Dyer's results, obtained on the surface-soils of the series of twenty-two plots, show at a glance comparative exhaustion or accumulation of both potash and phosphoric acid, whether hydrochloric acid, or the dilute citric acid solution, was used. There are, indeed, among these numerous results, some apparently inconsistent quantitative indications; but these are probably attributable to irregularities in the soils themselves, and therefore to the difficulties of sampling, rather than to those of analysis.

*Difficulty in sampling soils.*

It will be useful to refer a little more in detail to the results obtained on the soils of plot 2*a* and plot 4*a*; the manure and crop history of which has been pretty fully illustrated by the results given in Tables 29 and 30, and the discussion of them. It would appear that not more than two-thirds of the potash estimated to be accumulated where it was supplied, was taken up by hydrochloric acid; but that approximately the whole of the accumulated phosphoric acid was so taken up. Hence it may be judged that much of the residue of the supplied potash had gone into more fixed combinations within the soil than was the case with the phosphoric acid.

*Soil accumulation of potash and phosphoric acid.*

Then as to the citric acid results, it may be observed that they are so far accordant that the sample of the surface-soil of the potash-exhausted plot taken in 1882 showed more potash than that taken in 1889, when the exhaustion was of course greater. Again, the citric acid determinations on the soil with potash-supply showed more so taken up from the 1889 than from the 1882 sample; the accumulation having

[1] *Trans.* Chem. Soc., 1894, p. 115. See also the discussion on his paper, *Proc.* Chem. Soc., No. 134 (1893-94), p. 37.

been the greater at the later date. It is also of interest to observe that the amounts determined in the potash-exhausted soil by the 1-per-cent citric acid solution were about from three to five times as much as the crops would annually take up, which is a fairly consistent relation.

Further, with reference to these barley-soil results, as superphosphate was applied to both plots, the comparison of the amounts taken up on the two is of less interest than in the case of the potash; but comparison with the results obtained on another plot, otherwise similarly manured, but without superphosphate, shows, as already referred to, that the estimated accumulation of phosphoric acid was approximately indicated by the amount taken up by hydrochloric acid. The results relating to the two plots are, however, of special interest as illustrating, in the one case actual exhaustion, and in the other actual accumulation of potash, there being in the one a loss over the forty years of about 1018 lb. of the potash of the soil, and in the other a gain from supply of about 3180 lb.; whilst of the latter amount the results show that hydrochloric acid extracted nearly two-thirds, and citric acid less than one-fourth. It is further of interest to note that Dr Bernard Dyer's results, obtained on the 1882 samples from the two plots, in each case to the depth of three times 9 inches, agree with those formerly obtained by Hermann von Liebig on the wheat-field soils, in showing that little if any of either the potash or phosphoric acid artificially supplied had gone below the first 9 inches of depth.

*Accumulation of potash shown by soil-analysis.*

*Potash and phosphoric acid keep to the surface.*

*Analysis of wheat-soil.*

Dr Dyer is also working on the soils of some of the plots of the experimental wheat-field, and these will afford some striking illustrations in regard to the condition of availability of accumulated residue of potash-supply over a long series of years. Thus there is a series of plots which have received the same amount of ammonium-salts and superphosphate each year for forty years, to 1891 inclusive; one of which has received no potash either during those forty years, or during the eight preceding years; two received potash during the first eight years, but none since; and one, besides receiving potash during the first eight years, has received it each year since. The complete manure and crop history of each of the four plots is, so far as potash and phosphoric acid are concerned, available for each of the four ten-yearly periods of the forty years—as in the case of plots 2*a* and 4*a* in the barley-field. The amount and composition of the crops show great reduction in produce and exhaustion of potash, where none had been applied from the beginning; less reduction, and less exhaustion, where there was a residue of potash from the applications during the first eight years; and lastly, main-

tenance of produce, and great accumulation of potash in the crops, where potash has been annually applied. Further, the indication is, that the whole of the residue of potash supplied during the first eight years on the plots where none has been applied since, has been approximately exhausted during the succeeding forty years. It is obvious, therefore, that Dr Dyer will find new points of interest in the investigation of the experimental wheat-field soils; for the results will afford illustrations, not only of mere exhaustion and accumulation, but of effective residue as well.

### *On what does Strength of Straw Depend?*

It will be appropriate to refer here to the bearing of experimental evidence on the question whether, as is frequently stated, strength of straw is dependent on a high percentage of silica. Table 31 (p. 98) affords illustrations on this point. The upper division of the table gives results relating to wheat, and the lower corresponding results relating to barley. In the case of wheat five, and in that of barley three, very different conditions of manuring are selected for illustration; and, for each condition as to manuring, results obtained in bad and in good seasons are given. The particulars indicating the character of the crops are—the percentage of grain in the total produce, and the weight per bushel of the dressed grain; and, side by side with these are recorded—the percentage of ash in the dry matter of the straw, the percentage of silica in the ash, and the percentage of silica in the dry matter. *Silica and strength of straw.* *Table 31 explained.*

In the wheat in every case, and in the barley in every case but one, there is a higher proportion of grain in the better season; and in every case, of both wheat and barley, there is a much higher weight per bushel of grain in the better season. These conditions are, in fact, proof of the superiority of the crops in the main characters of seed-forming tendency, and ripening. *Season and produce.*

The percentage of ash in the dry matter of the straw is not a very significant character; and it is seen that in the case of the wheat it was on the average somewhat the lower, but in that of the barley uniformly the higher, in the better seasons. *Season and ash in straw.*

The percentage of silica in the ash of the straw is more significant; and in both the wheat and the barley it is, under all the conditions of manuring, much the lower in the better seasons. More significant still is the percentage of silica in the dry matter of the straw; and it is seen that with the wheat under each condition of manuring, and with *Silica in ash and dry matter of straw.*

the barley under most conditions, it is considerably lower in the better seasons. It may be observed that the exceptions in the case of the barley were, where organic manure, as in rape-cake and farmyard manure, was employed.

TABLE 31.

| | | Per cent grain in total produce. | Weight per bushel of dressed grain. | Per cent ash in dry matter. | Per cent silica in ash. | Per cent silica in dry matter. |
|---|---|---|---|---|---|---|
| **WHEAT.** | | | | | | |
| Without manure | 1856 | 36.4 | 54.3 | 5.5 | 71.47 | 3.93 |
| | 1858 | 40.6 | 60.4 | 4.9 | 65.85 | 3.23 |
| Ammonium-salts alone | 1856 | 34.8 | 55.5 | 3.9 | 66.23 | 2 58 |
| | 1858 | 40.3 | 59.6 | 4.0 | 57.47 | 2.30 |
| Mixed mineral manure | 1856 | 36.7 | 56.4 | 5.7 | 68.74 | 3.92 |
| | 1858 | 43.6 | 61.5 | 5.6 | 64.67 | 3.62 |
| Mineral manure and amm.-salts | 1856 | 33.6 | 58.0 | 4 9 | 64.63 | 3.17 |
| | 1858 | 38.2 | 62.2 | 5.0 | 55.60 | 2.78 |
| Farmyard manure | 1856 | 34.5 | 58.6 | 6.7 | 69.56 | 4.66 |
| | 1858 | 39.6 | 62.6 | 6.54 | 59.71 | 3.90 |
| **BARLEY.** | | | | | | |
| Rape-cake . . | 1852 | 44.3 | 51.7 | 4.75 | 57 49 | 2.73 |
| | 1871 | 45.4 | 56.3 | 5.54 | 42.04 | 2.33 |
| Rape-cake . . | 1856 | 39.1 | 46.1 | 4.63 | 49.39 | 2.29 |
| | 1863 | 48.4 | 56.3 | 5.17 | 45.62 | 2.36 |
| Mineral manure and amm.-salts | 1852 | 43.2 | 51.4 | 4.19 | 62 21 | 2.61 |
| | 1871 | 43.3 | 56.5 | 6.70 | 32.71 | 2.19 |
| Mineral manure and amm.-salts | 1856 | 40.2 | 46.4 | 5.48 | 57 47 | 3.15 |
| | 1863 | 47.3 | 56.5 | 6.32 | 35.24 | 2 23 |
| Farmyard manure | 1852 | 47.0 | 52.8 | 5.15 | 57.38 | 2.96 |
| | 1871 | 43.8 | 56.6 | 7.55 | 42.71 | 3 22 |
| Farmyard manure | 1856 | 42.8 | 47.1 | 4.92 | 57.85 | 2.85 |
| | 1863 | 48.3 | 57.2 | 6.21 | 43.08 | 2.68 |

*Season and silica in straw.*

Direct analytical results clearly show, therefore, that the proportion of silica is as a rule lower, not higher, in the straw of the better grown and better ripened crops.

*Strength of straw not dependent upon silica.*

This result is quite inconsistent with the usually accepted view that high quality and stiffness of straw depend on a high amount of silica. Pierre and Bretschneider have, indeed, concluded from their experiments that this is not the case, and at Rothamsted we have long maintained a contrary view. In fact, high proportion of silica means a relatively

low proportion of organic substance produced. Nor can there be any doubt that strength of straw depends on the favourable development of the woody substance; and the more this is attained the more will the accumulated silica be, so to speak, diluted—in other words, show a lower proportion to the organic substance.

*Woody matter and strength of straw.*

It may be mentioned that in our own neighbourhood, where the straw-plait industry prevails, the complaint during seasons of bad harvests has been that an unusually large proportion of the straw was brittle and broke in the working; and considering the character of the seasons, there can be no doubt that this was associated with low development of the woody matter, and high proportion of silica.

### *Summary and Conclusions.*

We have now illustrated the influence of exhaustion, of manures, and of variations of season, on the amounts of produce, and on the composition, of barley.

*Summary of results.*

The results have shown that on the growth of barley for more than forty years in succession on rather heavy ordinary arable soil, the produce by mineral manures alone was higher than that without manure; that nitrogenous manures alone gave more produce than mineral manures alone; and that mixtures of both mineral and nitrogenous manure gave much more than either used alone—indeed generally twice, or more than twice, as much as mineral manures alone. Of mineral constituents, whether used alone or in mixture with nitrogenous manures, phosphates were much more effective than mixtures of salts of potash, soda, and magnesia. The averages show that, under all conditions of manuring (excepting with farmyard manure) the produce was less over the later than over the earlier periods of the experiments, a result partly due to the seasons. But the average produce for the forty years of continuous growth of barley was, in all cases where nitrogenous and mineral manures (containing phosphates) were used together, much higher than the average produce of the crop grown in ordinary rotation in the United Kingdom, and very much higher than the average in most other countries when so grown.

*Most effective manures for barley.*

It is seen that the requirements of barley within the soil, and its susceptibility to the external influences of season, are very similar to those of its near ally, wheat. There are, however, distinctions of result dependent on differences in the habits of the two plants, and in the conditions of their cultivation accordingly.

*Barley and wheat contrasted.*

Wheat is with us, as a rule, sown in the autumn, on a

*Root-range of wheat.* heavier soil, and has four or five months in which to distribute its roots, and so gets possession of a wide range of soil and subsoil, before barley is sown.

*Barley a surface-feeder.* Barley is sown in a lighter surface-soil, and, with its short period for root-development, relies in a much greater degree on the stores within the surface-soil. Accordingly, it is more susceptible to exhaustion of surface-soil as to its nitrogenous, and especially as to its mineral, supplies; and in the common practice of agriculture it is found to be more benefited by direct mineral manures, especially phosphatic manures, than is wheat when sown under equal soil conditions.

*Manures requisite for wheat and barley.* The exhaustion induced by both crops is, however, characteristically that of available nitrogen; and when, under the ordinary conditions of manuring and cropping, artificial manure is still required, nitrogenous manures are, as a rule, requisite for both crops, and for the spring-sown barley, superphosphate also.

*Soils for wheat and barley.* Lastly, although barley is appropriately grown on lighter soils than wheat, good crops, of fair quality, may be grown on the heavier soils after another grain crop, by the aid of artificial manures, provided that the land is sufficiently clean.

## *SECTION III.—EXPERIMENTS ON THE GROWTH OF VARIOUS LEGUMINOUS CROPS FOR MANY YEARS IN SUCCESSION ON THE SAME LAND, ALSO ON THE QUESTION OF THE FIXATION OF FREE NITROGEN.*

### INTRODUCTION.

We now come to the third element of the ordinary four-course rotation—namely, Leguminous Crops, which, indeed, have a place in most other rotations also.

*Characteristics of different crops.* It is found that, within certain limits, the requirements, and the results of growth, of different members of one and the same family show certain characteristics in common; whilst those of different families show more or less of distinctive character. Nevertheless there are some important points of similarity, as well as of contrast, between the requirements of the agricultural representatives of the Gramineæ, the Cruciferæ, the Chenopodiaceæ, and the Solaneæ.

It will be seen, however, that the agricultural representatives of the Leguminosæ, all of which are included in the sub-order Papilionaceæ, and some of which are of much importance in our agriculture, show very marked differences as compared with those of any of the other Orders above enumerated.

*Leguminous plants and nitrogen.*

It so happens that both the scientific interest and the practical value of these crops, whether as elements in rotation, or as grown in the mixed herbage of grass-land, depend very largely on the amount of nitrogen which they contain, and on the sources of their nitrogen; and especially on the great differences in these respects between them and the representatives of the other Orders with which they are grown, either in alternation in our rotations, or in association in our meadows and pastures.

So much is this the case, that it is essential to a proper understanding and appreciation of the characteristics of growth of these crops, and for the illustration of their value and importance as depending on those characteristics, to compare and to contrast the conditions and results of their growth with those of the crops of other Orders.

We will, therefore, first briefly call attention to the difference in the amounts of nitrogen assimilated over a given area by different crops when each is grown for many years in succession on the same land without any nitrogenous manure—that is to say, under conditions in which the soil is to a great extent exhausted of accumulations of nitrogen due to recent supplies by manure, and when, therefore, the plants have to rely largely on what may be called the natural resources of the soil, and on those of the atmosphere.

### *Yield of Nitrogen per acre in different Crops.*

*Yield of nitrogen in different crops.*

Table 32 (p. 102) shows the yield of nitrogen per acre per annum, with mineral, but without any nitrogenous manure—in wheat and in barley as gramineous crops, in turnips as representatives of the Cruciferæ, in sugar-beet and mangel-wurzel of the Chenopodiaceæ, and in beans and clover as leguminous crops, when each is grown for many years in succession on the same land.

*Gradual exhaustion of nitrogen.*

Incidentally it is to be noticed that in the case of each of the crops—*wheat*, *barley*, and *beans*—thus grown year after year on the same land for many years in succession without nitrogenous manure, there was a reduction in the yield of nitrogen per acre per annum over the second period compared with the first; that is, as the previous accumulations within the soil became reduced.

*Yield of nitrogen in wheat and barley.*

Disregarding this tendency to reduced yield, it is seen that over the same period of 24 years, with full mineral but without nitrogenous manure, the wheat yielded an average of 22.1 lb., and the barley 22.4 lb. of nitrogen per acre per annum; the two allied crops, therefore, yielding almost identical amounts in their above-ground produce without

nitrogenous manure, on soil very poor in available nitrogen, so far as accumulations due to recent applications of nitrogenous manure are concerned.

TABLE 32.—NITROGEN PER ACRE PER ANNUM, IN VARIOUS CROPS GROWN AT ROTHAMSTED, WITH MINERAL BUT WITHOUT NITROGENOUS MANURE.

| | | Duration of experiment. | Average nitrogen per acre per annum. |
|---|---|---|---|
| | | | lb. |
| Wheat | | 12 years, 1852-63 | 27.0 |
| | | 12 years, 1864-75 | 17.2 |
| | | 24 years, 1852-75 | 22.1 |
| Barley | | 12 years, 1852-63 | 26.0 |
| | | 12 years, 1864-75 | 18.8 |
| | | 24 years, 1852-75 | 22.4 |
| Root-crops | Swedish turnips | *15 years, 1856-70 | 18.5 |
| | Sugar-beet | 5 years, 1871-75 | 14.7 |
| | Mangels | 10 years, 1876-85 | 14.0 |
| | Total | 30 years, 1856-85 | 16.4 |
| Beans | | 12 years, 1847-58 | 61.5 |
| | | †12 years, 1859-70 | 29.5 |
| | | 24 years, 1847-70 | 45.5 |
| Clover | | ‡22 years, 1849-70 | 39.8 |

* 13 years, 2 years failed.
† 9 years beans, 1 year wheat, 2 years fallow.
‡ 6 years clover, 1 year wheat, 3 years barley, 12 years fallow.

*Yield of nitrogen in root-crops.*

Turning now to the yield of nitrogen in the root-crops—turnips, sugar-beet, and mangel-wurzel—it may be mentioned that prior to the period referred to in the table, turnips had been grown for a number of years, and had yielded 42 lb. of nitrogen per acre per annum, due to the accumulations from comparatively recent nitrogenous manuring. But it is seen that after these accumulations had been reduced, swedish turnips gave, over 15 years, an average of only 18.5 lb.; sugar-beet over the next 5 years, an average of only 14.7 lb.; and mangel-wurzel over the succeeding 10 years, an average of only 14.0 lb. of nitrogen per acre per annum. Or, reckoned

over the whole period of 30 years, after the recent accumulations had been worked out, the root-crops gave an average of only 16.4 lb. of nitrogen per acre per annum.

*Similarity in amount of nitrogen in grain and root-crops.*

It is remarkable how very similar is the amount of nitrogen annually accumulated in gramineous, cruciferous, and chenopodiaceous crops, after the soil had been exhausted of the more recent and more readily available nitrogenous accumulations. Thus, over the second half of the period, the wheat gave 17.2 lb., and the barley 18.8 lb., against 16.4 lb. over 30 years in the various root-crops.

*Yield of nitrogen in leguminous crops.*

We now come to the yield of nitrogen in leguminous crops. Referring first to the results obtained with beans, it is seen that over the first half of the period of 24 years, the average annual yield of nitrogen in the crop was 61.5 lb. per acre; whilst over the second 12 years—in 3 of which the crop failed, so that there were only 9 years of beans, one of wheat, and two of fallow—the annual yield was less than half as much, or only 29.5 lb. per acre. Nevertheless, the average yield over the 24 years without any nitrogenous manure, was 45.5 lb. per acre per annum. That is to say, under very similar conditions as to soil-supply, the highly nitrogenous leguminous crop, beans, has yielded over a given area twice as much nitrogen as either wheat or barley, and more than twice as much as the root-crops.

*Clover sickness.*

The last results in the table relate to the leguminous crop —clover. It is well known that clover fails when it is attempted to grow it too frequently on the same land; and, in the case recorded in the table, it happened that clover was obtained in only 6 years out of the 22 for which the yield of nitrogen is given; so that there are included, owing to the failures, 1 year of wheat, 3 of barley, and 12 of fallow. Notwithstanding this, there was, with the occasional interpolation of the clover, an average yield over the 22 years of 39.8 lb. of nitrogen per acre with mineral, but without nitrogenous supply.

*Yield of nitrogen from clover.*

*Yields of nitrogen from barley and clover compared.*

The next illustrations show more strikingly still the greater yield of nitrogen in leguminous than in gramineous crops, when grown under equal soil conditions. They relate to the yield of nitrogen in barley and in clover, grown side by side in the same field; and the results are given in Table 33.

The field had grown one crop of wheat, one of oats, and three of barley in succession, with artificial mineral and nitrogenous manures; but without any farmyard or other organic manure. In 1872 barley was again sown; on one half alone, and on the other half with clover. In 1873 barley was again grown on the one half, but the clover on the other.

The table shows that the barley yielded 37.3 lb. of nitrogen per acre, whilst the three cuttings of clover contained 151.3 lb. In the next year, 1874, barley was grown over both portions; and on the one where barley had yielded 37.3 lb. of nitrogen in the previous year, it now yielded 39.1 lb.; but on the portion where the clover had yielded 151.3 lb., the barley succeeding it yielded 69.4 lb. That is to say, the barley yielded 30.3 lb. more nitrogen after the removal of 151.3 lb. in clover, than after the removal of only 37.3 lb. in barley.

TABLE 33.—NITROGEN PER ACRE IN BARLEY AND IN CLOVER, GROWN IN LITTLE HOOSFIELD, ROTHAMSTED.

| | | | Nitrogen per acre. |
|---|---|---|---|
| | | | lb. |
| 1873 | Barley | | 37.3 |
| | Clover | | 151.3 |
| 1874 | Barley | After barley | 39.1 |
| | | After clover | 69.4 |
| | Barley after clover more than after barley | | 30.3 |

*Clover enriching soil in nitrogen.*

The fact is, that the clover had not only yielded so much more nitrogen in the removed crops, but it had also left the surface-soil considerably richer in nitrogen. Thus in October 1873, after the removal of the barley and the clover, samples of soil were taken from ten places on each of the two portions, and the nitrogen was determined in the samples—from each of four of the individual holes separately, in the mixture of the four, and in the mixture of the samples from the other six places. The determinations in the numerous separate samples consistently showed that, to the depth of 9 inches, the clover-land-soil, which had yielded so much more nitrogen in the crops, was nevertheless determinably richer in nitrogen than the barley-land-soil, which had yielded so much less. This is sufficiently illustrated by the following figures, showing the mean percentage of nitrogen in October 1873, in the fine dry soil, of the clover-land, and of the barley-land, respectively:—

| | Mean per cent nitrogen. |
|---|---|
| In clover-land-soil | 0.1566 |
| In barley-land-soil | 0.1416 |

This was the case notwithstanding that all visible vegetable *débris* had first been removed from the samples. It was

further found that the above- and under-ground vegetable residue picked from the clover-land samples was much more in quantity, and contained much more nitrogen, than that from the barley-land samples.

*Further similar results.*

In 1874, and in 1875, barley only was sown over both portions. In 1876, barley was again sown over the whole of the land, with clover as well on the portions where it had grown in 1873; but the plant failed in the winter, and gave no crop in 1877. In 1877, barley was again sown over the whole; this time with clover on half of the previously clover portion, and on half of the previously only barley portion. In the autumn of 1877 soil-samples were again taken; this time from four places on each of the differently cropped portions. The determinations of nitrogen in the surface-soils consistently showed, as before, a higher percentage where clover than where only barley had grown.

*Nitrogen in leguminous and gramineous crops.*

It is, of course, well known in agriculture, that the growth of clover, which removes much more nitrogen than a cereal crop, increases the produce of a succeeding cereal as if nitrogenous manure had been applied. But attention is specially to be directed to the fact, that a leguminous crop accumulates a great deal more nitrogen over a given area than a gramineous one under equal soil-conditions.

But not only is the yield of nitrogen per acre much less in the cereal crops, but the percentage of nitrogen in the dry substance of the gramineous produce is much less than in that of the leguminous produce.

The corn of the leguminous crops—beans and peas, for example—contains more than twice as high a percentage of nitrogen in its dry substance as that of the gramineous grains. The dry substance of leguminous straws also contains about twice as high a percentage of nitrogen as that of cereal straws. Again, the dry substance of clover-hay contains not far short of twice as much nitrogen as that of meadow-hay. Lastly, the dry substance of roots contains about the same percentage of nitrogen as that of the cereal grains, but only about half as much as that of the leguminous corn. The leaves of the root-crops are, however, high in nitrogen.

The general result is, then, that the *non*-leguminous crops, especially those of the gramineous family, are characterised, both by yielding much less nitrogen in their produce over a given area, and by containing a much lower percentage of nitrogen in their dry substance, than the leguminous crops. Bearing these facts in mind, let us now turn to the consideration of the effects of direct nitrogenous manures on the various crops.

### *Effects of Nitrogenous Manures in increasing the Produce of various Crops.*

*Effects of nitrogenous manures upon various crops.*

It is fully recognised that, under the conditions in which the crops are grown in ordinary agriculture, nitrogenous manures have very marked effects in increasing the amounts of produce of wheat, of barley, of turnips, of mangels, and of potatoes—that is, of the comparatively low-in-nitrogen *non*-leguminous crops. It is to be borne in mind, too, that in the case of wheat and barley the increased produce consists characteristically of the non-nitrogenous substances starch and cellulose, in that of the root-crops of the non-nitrogenous substance sugar, and in that of potatoes of the non-nitrogenous substance starch.

The influence of nitrogenous manures in increasing the production of the non-nitrogenous constituents of our crops is very strikingly illustrated by the results given in Table 34.

*Table 34 explained.*

The first column of figures shows—the estimated amounts of carbon per acre per annum, in the total produce of wheat and of barley, in the roots of sugar-beet and mangel-wurzel, in the tubers of potatoes, and in the total produce of beans, when each is grown by a complex mineral manure without nitrogen, and also with the same mineral manures with nitrogenous manure in addition. The second column shows the estimated gain of carbon—that is, the increased amount of it assimilated under the influence of the nitrogenous manures. The third column gives the estimated increased production of total carbohydrates, under the influence of the nitrogenous manures; and the last column the estimated gain of carbohydrates for 1 of nitrogen in manure. The calculations are based on the average produce by the different manures, of wheat over 20 years, of barley over 20 years, of sugar-beet over 3 years, of mangel-wurzel over 8 years, of potatoes over 10 years, and of beans over 8 years.

*Method of calculation.*

The mode of calculating the amounts of carbon and of carbohydrates is as follows: From the amount of dry substance in the crops, the amounts of mineral matter and of nitrogenous substance are deducted; and the remainder represents the amount of carbohydrates. The amount of carbon in the nitrogenous substance is calculated, and then that in the carbohydrates, on the assumption that, in the wheat, barley, and beans, starch and cellulose are the main products; in the sugar-beet and mangel-wurzel, cane-sugar, pectine, and cellulose; and in the potatoes, starch and cellulose. Such estimates can, obviously, be only approximations to the truth; but, accepted as such, they are useful, as conveying some

definite impression of the influence of nitrogenous manures on carbon-assimilation, and on carbohydrate-formation.

TABLE 34.—ESTIMATES OF THE YIELD AND GAIN OF CARBON, AND OF THE GAIN OF CARBOHYDRATES, PER ACRE PER ANNUM, IN VARIOUS EXPERIMENTAL CROPS GROWN AT ROTHAMSTED.

| | Carbon. | | Carbohydrates. | |
|---|---|---|---|---|
| | Actual. | Gain. | Gain. | For 1 nitrogen in manure. |
| **WHEAT 20 YEARS, 1852-71.** | | | | |
| | lb. | lb. | lb. | lb. |
| Mineral manure | 988 | .. | ... | ... |
| Mineral manure and 43 lb. nitrogen as ammonia | 1590 | 602 | 1240 | 28.8 |
| Mineral manure and 86 lb. nitrogen as ammonia | 2222 | 1234 | 2550 | 29.7 |
| Mineral manure and 86 lb. nitrogen as nitrate | 2500 | 1512 | 3140 | 36.5 |
| **BARLEY 20 YEARS, 1852-71.** | | | | |
| Mineral manure | 1138 | ... | ... | .. |
| Mineral manure and 43 lb. nitrogen as ammonia | 2088 | 950 | 1992 | 46.3 |
| **SUGAR-BEET 3 YEARS, 1871-73.** | | | | |
| Mineral manure | 1123 | .. | . | . |
| Mineral manure and 86 lb. nitrogen as ammonia | 2600 | 1477 | 3188 | 37.1 |
| Mineral manure and 86 lb. nitrogen as nitrate | 3031 | 1908 | 4052 | 47.1 |
| **MANGEL-WURZEL 8 YEARS, 1876-83.** | | | | |
| Mineral manure | 759 | ... | ... | . |
| Mineral manure and 86 lb. nitrogen as ammonia | 1889 | 1130 | 2376 | 27.6 |
| Mineral manure and 86 lb. nitrogen as nitrate | 2129 | 1370 | 2771 | 32.2 |
| **POTATOES 10 YEARS, 1876-85.** | | | | |
| Mineral manure | 1021 | .. | . | . |
| Mineral manure and 86 lb. nitrogen as ammonia | 1783 | 762 | 1507 | 17.5 |
| Mineral manure and 86 lb. nitrogen as nitrate | 1752 | 731 | 1416 | 16.5 |
| **BEANS 8 YEARS, 1862 AND 1864-70.** | | | | |
| Mineral manure | 726 | ... | ... | ... |
| Mineral manure and 86 lb. nitrogen as nitrate | 992 | 266 | 474 | 5.5 |

It is thus seen that, independently of the underground growth, the wheat was estimated to assimilate 988 lb. of

*Yield of carbon with and without nitrogenous manure.*

carbon per acre per annum, under the influence of a complex mineral manure alone; and that the amount was increased to 1590 lb. by the addition of 43 lb. of nitrogen as ammonium-salts, to 2222 lb. by 86 lb. of nitrogen as ammonium-salts, and to 2500 lb. by 86 lb. of nitrogen as sodium-nitrate. Accordingly, as shown in the second column, the increased assimilation of carbon was—by 43 lb. of nitrogen as ammonium-salts 602 lb., by 86 lb. as ammonium-salts 1234 lb., and by 86 lb. as sodium-nitrate 1512 lb.

Reckoned in the same way, the increased assimilation of carbon in the barley was, for 43 lb. nitrogen as ammonium-salts 950 lb. per acre—that is, one and a-half time as much as by the same application in the case of wheat.

In the sugar-beet, the roots only (the leaves being left on the land), the increased assimilation of carbon was 1477 lb. per acre by the application of 86 lb. nitrogen as ammonium-salts, and 1908 lb. by 86 lb. nitrogen as sodium-nitrate. There was, therefore, considerably more increased assimilation of carbon, and accumulation of it in the roots of the sugar-beet, than in the grain and straw of wheat, by the same applications of nitrogenous manure.

In mangel-wurzel roots (the leaves being returned to the land), the increased assimilation of carbon was 1130 lb. by 86 lb. of nitrogen as ammonium-salts, and 1370 lb. by 86 lb. as nitrate—that is, less than in the removed crops (grain and straw) of wheat, and considerably less than in the removed crops (the roots) of sugar-beet.

In the potatoes, reckoned on the increased production of tubers only (the tops being left on the land), the increased yield of carbon by 86 lb. of nitrogen as ammonium-salts was 762 lb. per acre, and by 86 lb. as sodium-nitrate 731 lb.—that is, there was considerably less increased production of starch in potatoes than of sugar in either sugar-beet or mangel-wurzel by the same applications of nitrogenous manure.

Lastly, in the leguminous crop—beans, with its high yield of nitrogen per acre, and the high percentage of nitrogen in its dry substance—the increased assimilation of carbon under the influence of nitrogenous manure was comparatively quite insignificant. Thus there was, by the application of 86 lb. of nitrogen as sodium-nitrate, an increased assimilation of carbon of only 266 lb. per acre, or little more than one-sixth as much as in wheat, and little more than one-eighth as much as in sugar-beet, by the same application.

*Yield of carbohydrates with and without nitrogenous manure.*

Turning to the figures in the third column, it is seen that there was a very greatly increased production of the non-nitrogenous bodies, the carbohydrates, by the use of nitrogenous manures.

Thus, by the use of 43 lb. of nitrogen as ammonium-salts, there was an estimated increase of 1240 lb. of carbohydrates in the grain and straw of wheat, and of 1992 lb. in those of barley. By the application of 86 lb. of nitrogen as ammonium-salts, there was an increased formation of 2550 lb. of carbohydrates in wheat, of 3188 lb. in sugar-beet, of 2376 lb. in mangel-wurzel, and of only 1507 lb. in potatoes; and when 86 lb. were applied as sodium-nitrate, there was an increased production of 3140 lb. in wheat, of 4052 lb. in sugar-beet, of 2771 lb. in mangel-wurzel, and of only 1416 lb. in potatoes. Whilst, compared with these amounts, there was by the same application, an increase of only 474 lb. of carbohydrates in beans.

The last column shows the estimated increased amounts of carbohydrates produced for 1 of nitrogen in manure, in the different cases. Thus, when 43 lb. of nitrogen were applied as ammonium-salts, 1 lb. of nitrogen in manure gave an increased production of 28.8 lb. of carbohydrates in the grain and straw of wheat, and of 46.3 lb. in those of barley; when 86 lb. nitrogen were applied as ammonium-salts, 1 lb. gave an increase of 29.7 lb. carbohydrates in wheat, 37.1 lb. in the roots of sugar-beet, 27.6 lb. in those of mangel-wurzel, and 17.5 lb. in potatoes. Again, when 86 lb. were applied as sodium-nitrate, 1 lb. gave an increase of 36.5 lb. carbohydrates in wheat, 47.1 lb. in sugar-beet, 32.2 lb. in mangel-wurzel, 16.5 lb. in potatoes, and only 5.5 lb. in the leguminous crops—beans.

*Seemingly anomalous results explained.*

It is natural to ask, What is the explanation of the apparently anomalous result, that the crops which are characterised by containing comparatively little nitrogen, and by yielding large amounts of non-nitrogenous products—starch, sugar, and cellulose—are especially benefited by the application of nitrogenous manures; and that, under their influence, they yield greatly increased amounts of those non-nitrogenous bodies?

It is, perhaps, little more than stating the facts in another way to say, as is the case, that the luxuriance or activity of growth of all these crops is very greatly enhanced by nitrogenous manures; and that, since their special products are these non-nitrogenous substances, the natural result of the increased luxuriance is to increase the formation of the bodies which are their essential or characteristic products.

A further possible explanation of the curious result has, however, been suggested.[1]

Thus, on purely chemical and physiological grounds, and

[1] See Vines' Lectures on the *Physiology of Plants*, p. 140 *et seq.*

*Vines' views.* so far as would appear without any special reference to the fact that, in the case of our chief starch- and sugar-yielding crops, the production of those substances is greatly enhanced by the use of nitrogenous manures, it has been suggested that the substance first formed in the chlorophyll-corpuscle from carbon dioxide and water is not starch, but a substance possibly allied to formic aldehyde ($CH_2O$), which goes to construct proteid, by combining with the nitrogen and sulphur absorbed in the form of salts from the soil, or with the nitrogenous residues of previous decompositions of proteid. It is supposed, however, that starch may nevertheless be the first *visible* product of the constructive metabolism; since, unless protoplasm were being formed, no starch could be produced.

This view is partly founded on the consideration of the analogy that would then be established between the formation of starch and that of the carbohydrate—cellulose, which is by some experimenters supposed to be derived directly from protoplasm.

It is true that such a supposition is at any rate not inconsistent with the conditions which we have seen to be favourable for the increased production of starch and sugar in agricultural plants. At the same time, it is admittedly at present little more than hypothesis. It would, indeed, require more evidence than is at present available, to establish such a conclusion; whilst there are considerations which would lead us to hesitate to adopt the view in question without clear experimental proof.

Thus, it seems difficult to suppose that the undoubted connection in some striking cases between the amount of nitrogen taken up by the plant, and the amount of starch or sugar formed, is to be explained by an assumption which implies that a chief office of the nitrogenous bodies of plants is to serve as intermediate only, in the transformations necessary for the formation of the non-nitrogenous substances. The view does not, however, assume that nitrogen is eliminated from the plant in the process, and so lost. Then, again, plants, such as many of the Leguminosæ, which are characterised by assimilating relatively very large amounts of nitrogen over a given area of land, and by the formation of very large amounts of proteid in proportion to plant surface, produce relatively small amounts of the carbohydrates.

*An analogy from the animal world.* Nor is it irrelevant to refer to the fact that, from theoretical considerations, it was for many years assumed, especially in Germany, in opposition to the teachings of our own numerous direct experiments, that in the animal body the non-nitrogenous substance—fat—was mostly, if not always,

produced by the degradation of proteid; the nitrogenous by-products being for the most part, if not entirely, eliminated from the body as waste matter. It is, however, now indubitably established, at any rate in the case of the herbivora which produce the most fat, that that substance is derived largely, if not exclusively, from the non-nitrogenous constituents of the food—the carbohydrates.

In the case of the supposed transformation in plants, the same prodigal expenditure of the nitrogenous bodies in the formation of the non-nitrogenous is, however, as has been said, not involved.

### *Effects of Nitrogenous Manures on Leguminous Crops.*

We have now to illustrate the influence of nitrogenous manures on various leguminous crops which, as has been pointed out, are characterised by containing a high percentage of nitrogen in their dry substance, and by assimilating a large amount of nitrogen, from some source, over a given area of land. It will be seen that the results bring to view some very remarkable failures, but also some not less signal and significant successes.

*Effects of nitrogenous manures on beans.*

Our first illustrations relate to experiments with *beans*, grown for many years in succession on the same land, without manure; with a purely mineral manure (consisting of superphosphate, and salts of potash, soda, and magnesia); also with the same mineral manure, and nitrogenous manure in addition, supplied either as ammonium-salts or as sodium-nitrate. Table 35 (p. 112) gives a summary of the results obtained under each of the three conditions as to manuring over a period of 32 years of continued or interrupted experiments, from 1847 to 1878 inclusive. The upper division gives the average amount of total produce (corn and straw together) per acre per annum, over each of the four 8-yearly periods, and over the total period of 32 years. But, as there were frequent failures of crop, the lower division of the table gives the average produce per acre per annum over the years of crop only during each period.

*Nitrates more effective than ammonium-salts.*

Before referring to the figures, it should be explained that in the first 5 years the nitrogen applied to the third plot was in the form of ammonium-salts. The effects were, however, so small and irregular, that the application of nitrogenous manure was then suspended for some years—indeed for 10 years; after which, it having been observed that nitrates were more beneficial to Leguminosæ than ammonium-salts, sodium-nitrate was applied instead; in amount supplying 86 lb. nitrogen per acre per annum, or nearly twice as much

as had been given as ammonium-salts in the earlier years. This application of the nitrate commenced in 1862, and with some breaks owing to severe or wet winters, which prevented the seed being sown or destroyed the plant, it was continued up to 1878, when the experiments were finally abandoned.

TABLE 35.—BEANS. Average Produce per acre per annum in lb.

| | Total produce (corn and straw). | | |
|---|---|---|---|
| | Unmanured. | Mixed mineral manure (including potash). | Mixed mineral manure and nitrogen. |
| AVERAGE PER ACRE PER ANNUM, over each 8 years, and over the 32 years. | | | |
| | lb. | lb. | lb. |
| 8 years, 1847-54 . . . . | 2421 | 3208[1] | 3555 |
| 8 years, 1855-62 . . . . | 1664 | 2466 | 2629 |
| 8 years, 1863-70 . . . . | 606 | 1622 | 2198 |
| 8 years, 1871-78 . . . . | 864 | 1506 | 1646 |
| 32 years, 1847-78 . . . . | 1389 | 2168[2] | 2507 |
| AVERAGE PER ACRE PER ANNUM, over the years of crop only, each period. | | | |
| 1st 8 years, 8 crops . . . . | 2421 | 3208[3] | 3555 |
| 2nd 8 years, 7 crops . . . . | 1902 | 2818 | 3005 |
| 3rd 8 years, 7 crops . . . . | 692 | 1854 | 2513 |
| 4th 8 years, 4 crops . . . . | 1729 | 3011 | 3292 |
| 32 years, 1847-78, 26 crops . | 1709 | 2688[4] | 3086 |

[1] 7 years, excluding 1849, in which year the produce was accidentally not weighed.
[2] 31 years, excluding 1849. [3] 7 crops, excluding 1849.
[4] 25 crops, excluding 1849.

*Failure of leguminous crops grown at short intervals.*

The occasional entire failures above referred to as mainly due to adverse seasons, were also materially dependent on the conditions induced in the land by the continuous cropping with this plant; which, as is the case with most Leguminosæ, is very susceptible to parasitic attacks of various kinds when the conditions of growth are not normal and favourable. Indeed, when there was not absolute failure, there was a general tendency to decline in yield, and then to recover again more or less after a break. This was somewhat marked after a year of fallow in 1860, and the growth of wheat in 1861; after which there was, in 1862, fair produce, especially on the third plot, where the nitrate was now applied. The land was again fallow in 1863, and this was

again followed by improved growth, after which there was declining produce for a number of years to 1870 inclusive, and again recovery in 1874 after 3 years of fallow. This general view of the results is of interest, as fixing attention on the great tendency to failure of this leguminous crop, when grown year after year on the same land.

Independently of the occasional entire failures, there were also considerable fluctuations from year to year according to season; and the table shows that there was, besides, upon the whole considerable decline from period to period. Turning now to the effects of the different manures, it is seen that there was, over each period, a considerable increase of produce by the use of the mineral manure containing potash, but that there was comparatively little further increase by the addition of nitrogenous to the mineral manure. Thus, as shown in the upper division of the table, the average annual total produce over the 32 years (which, however, included 7 without any bean crop) was—without manure 1389 lb., with the mineral manure alone 2168 lb., and with the mineral and nitrogenous manure together 2507 lb. That is, whilst the mineral manure without nitrogen gave an average annual increase of 779 lb., the addition to it of nitrogenous manure only further raised the produce by 339 lb.

*Increased produce from mineral manure.*

*Little increase from nitrogenous manure.*

Or if, instead of taking the average of the 32 years, we take it only over the 26 years in which there was any bean crop, as shown in the lower division, the average total produce was—without manure 1709 lb., with purely mineral manure 2688 lb., and with the mineral and nitrogenous manure together 3086—that is, there was an annual average increase of 979 lb. by the mineral manure containing potash, and of only 398 lb. more by the addition of nitrogenous manure.

It may be added that details not given in the table further show, that in two of the last 8 years the total produce was, without manure, only exceeded three or four times during the whole period—namely, during the first five years; with mineral manure alone, it was only exceeded four or five times; and with the mineral and nitrogenous manure together, it was only exceeded six times. Indeed the table shows that on both of the manured plots the average total produce over the last 4 years of actual crop (with 4 of fallow in the 8 years) was nearly as much as the average of the first 8 years of crop. Thus, with the purely mineral manure, the average total produce of the first 8 years was 3208 lb., and over the last 4 years of crop it was 3011 lb.; and with the mineral and nitrogenous manure it was, over the first 8 years 3555 lb., and over the last 4 years of

crop 3292 lb. It will be seen further on that the average annual yield of nitrogen was also nearly as great over the last 4 years of crop as over the first 8 years.

*Ammonium-salts unsuitable for leguminous crops.*

It may be observed that nitrogen supplied as ammonium-salts to the highly nitrogenous leguminous crop seldom gives any increase, and is sometimes injurious in the year of application; though some benefit may afterwards result from the residue after the ammonia has been converted into nitric acid. Even nitrates, however, directly applied as manure, are very uncertain in their action, and at any rate yield very much less increase of produce with the highly nitrogenous Leguminosæ than with the Gramineæ, and crops of other Orders yielding produce of low percentage of nitrogen in their dry substance, and accumulating comparatively little nitrogen over a given area of land.

*Nitrates uncertain.*

*Continuous cropping with beans a failure.*

It is specially to be noted, that whilst the cereal crops may be successfully grown for many years in succession on the same land, provided only that mineral and nitrogenous manures are liberally supplied, this leguminous crop—beans—gradually fails when so grown; and although characteristically benefited by mineral manures containing potash, neither these alone, nor a mixture of mineral and nitrogenous manure, has sufficed to maintain even fair growth for a number of years in succession. The result is, however, not entirely due to deficiency in the supply of constituents within the soil, but is also in a considerable degree dependent on the fact that, by the continuous growth of the crop, with its special habit and range of roots, the surface-soil acquires a close and unfavourable condition, and a somewhat impervious pan is formed below. The improved result in the later years with the intervention of fallow, further illustrates the fact that the previous failures were not wholly due to exhaustion.

*The reason why.*

*Amount of nitrogen in bean crops.*

The next Table (36) shows the amounts of nitrogen in the bean crops, the produce of which we have been considering. The table is on the same plan as that relating to the produce; the upper division giving the averages for the four 8-yearly periods, and for the total period of 32 years, and the lower division those for the years of crop only, within each period; and, as in Table 35, the results for the total produce only (corn and straw together) are given.

Referring to the figures in the upper division of the table, it may be observed that, notwithstanding there were 6 blank years, and one year of wheat, out of the 32, and notwithstanding that the produce declined much, and gave on the whole much less than the average obtained under ordinary agricultural conditions, yet the average yield of nitrogen in the crops grown without any supply of it was much more than

in either of the cereals, the root-crops, or potatoes, grown under similar conditions.

*Yields of nitrogen without manure, with mineral manure, and with nitrogenous manure.*

Thus, as the bottom line of the upper division shows, there was an average over the 32 years, of 24.8 lb. of nitrogen per acre per annum in the crops without any manure, but of 35.4 lb. with the mineral manure without nitrogen; whilst the amount was raised to only 42.4 lb. by the addition of nitrogenous manure. Over the first 8 years, however, the yield was very much higher, being for the three plots respectively 48.4, 60.2, and 69.0 lb. Over the second period of 8 years the average was not far from that of the whole 32 years, but over the third and fourth periods it was much less.

TABLE 36.—BEANS. YIELD OF NITROGEN, AVERAGE PER ACRE PER ANNUM, LB. 8-YEAR PERIODS.

| | Total produce (corn and straw). | | |
|---|---|---|---|
| | Unmanured. | Mixed mineral manure (including potash). | Mixed mineral manure and nitrogen. |
| AVERAGE PER ACRE PER ANNUM, over each 8 years, and over the 32 years. | | | |
| | lb. | lb. | lb. |
| 8 years, 1847-54 . . . . | 48.4 | 60.2[1] | 69.0 |
| 8 years, 1855-62 . . . . | 25.3 | 34.3 | 36.8 |
| 8 years, 1863-70 . . . . | 9.2 | 23.5 | 35.1 |
| 8 years, 1871-78 . . . . | 16.4 | 26.7 | 28.7 |
| 32 years, 1847-78 . . . . | 24.8 | 35.4[2] | 42.4 |
| AVERAGE PER ACRE PER ANNUM, over the years of crop only, each period. | | | |
| 1st 8 years, 8 crops . . . . | 48.4 | 60.2[3] | 69.0 |
| 2nd 8 years, 7 crops . . . . | 28.9 | 39.2 | 42.1 |
| 3rd 8 years, 7 crops . . . . | 10.4 | 26.8 | 40.0 |
| 4th 8 years, 4 crops . . . . | 32.7 | 53.3 | 57.4 |
| 32 years, 1847-78, 26 crops . . | 30.5 | 43.9[4] | 52.2 |

[1] 7 years, excluding 1849, in which year the produce was accidentally not weighed.
[2] 31 years, excluding 1849.
[3] 7 crops, excluding 1849.
[4] 25 crops, excluding 1849.

As in the case of the total produce itself, so also in that of the nitrogen in the total produce, if we take the averages of the years of crop only, as given in the bottom division of the table, we have a much higher average yield per annum over the 4 years of crop of the last 8 years, than over the years of

crop of either the second or the third period of 8 years. Indeed, on the two manured plots there is an average annual yield of nitrogen per acre over the 4 years of crop during the last 8 years not very far short of the average of the first 8 years. Thus, with the purely mineral manure, there is an average annual yield of nitrogen over the first 8 years of 60.2 lb., and over the 4 years of crop of the last 8 of 53.3 lb.; and, with the mineral and nitrogenous manure together, over the first 8 years of 69.0 lb., and over the 4 years of crop of the last 8 years, of 57.4 lb.

*Influence of fallow on beans.*

That is, with the intervention of fallow, we have, though not good agricultural crops, yet really large yields of nitrogen compared with those obtained in many of the preceding years; and very large yields without any supply by manure, compared with those obtained under the same conditions with any of the *non*-leguminous crops. It would appear probable, therefore, that if a suitable mechanical condition of the land could have been maintained, fair crops, and large yields of nitrogen, would also have been maintained.

Upon the whole, then, although the crop practically failed when it was thus attempted to grow it year after year on the same land, it nevertheless accumulated, in its above-ground produce, much more nitrogen over a given area than the crops of the other Orders, but was little benefited by an artificial supply of nitrogen

*Failure of clover grown at short intervals.*

We have now to record a still greater failure than that with beans—namely, when it was attempted to grow another leguminous crop year after year on ordinary arable land—this time *Trifolium pratense*, or Red clover. The results are summarised in Table 37.

The table is headed Red clover, sown frequently on the same land. The period of experiment was in fact 29 years —from 1849 to 1877 inclusive. But the details, not given in the table, show that although clover was sown fifteen times in the 29 years, in only 7 was any clover crop obtained; whilst about one-fifth of the produce of the whole series of years was yielded in the first year, 1849. It is, indeed, fully recognised that in our own country clover will not grow under ordinary conditions more frequently than once in a certain number of years, which varies according to soil and other circumstances, but is seldom so few as four, and frequently as many as, or more than, eight years. It should be stated that when the clover failed, sometimes a cereal crop, wheat or barley, was sown; but more frequently the land was left fallow. Further, the amounts of produce entered in the column headed Series 1 are in each case the

means of those on three plots, each of which occasionally received a mineral manure containing potash; and the results given in the column Series 2 are also the means of three plots, each with the same mineral manure as Series 1, and nitrogenous manures occasionally applied in addition.

TABLE 37.—RED CLOVER. Sown frequently on the same land. Total Produce per acre per annum, as Hay.

| | | Series 1. Mineral manure alone. | Series. 2. Mineral and nitrogenous manures. |
|---|---|---|---|
| **Summary. Produce.** | | | |
| | | lb. | lb. |
| 29 years, 1849-77 . . | Total | 52,991 | 60,689 |
| | Average | 1,827 | 2,093 |
| Years of crop only . . | Average | 4,416 | 4,668 |
| Years of clover only (7) . | Total | 29,195 | 31,886 |
| | Average | 4,171 | 4,555 |
| **Summary. Nitrogen (estimated).** | | | |
| 29 years, 1849-77 . . | Total | 929.4 | 1,043.1 |
| | Average | 32.0 | 36.0 |
| Years of crop only . . | Average | 77.5 | 80.2 |
| Years of clover only (7) . | Total | 700.7 | 765.3 |
| | Average | 100.1 | 109.3 |

*Variations in the clover crop.*

It should be explained that very large crops of clover were obtained in the first year, 1849; less than one-quarter as much in the third year, 1851; and in the fourth about half as much as in the first. No more clover was then obtained until the seventh year, when there was very little. After this, there was more or less in the eleventh, seventeenth, twenty-third (on Series 2), and lastly, (on Series 1) in the twenty-seventh year; but in no case, excepting in the fourth year, was the amount of produce half as much as in the first.

*Effects of nitrogenous manure on clover.*

Comparing the results without and with the nitrogenous manure, the table shows that the average annual total produce of clover-hay, and other crops, was, reckoned over the 29 years, 1827 lb. without, and 2093 lb. with, the nitrogenous manure; and, reckoned in the same way, the average annual

yield of nitrogen was, without nitrogenous manure 32 lb., and with it 36 lb. Reckoned, however, over the years of crop only, the yield of nitrogen in the clover and other crops was 77.5 lb. per acre per annum without, and 80.2 lb. with, the nitrogenous manuring. Or, reckoning the nitrogen in the clover alone, and only over the years when it gave any crops, the average annual yield of it over those 7 years was, without nitrogenous manure 100.1, and with it 109.3 lb. There was, therefore, comparatively little increase, either in the produce, or in the yield of nitrogen, by the use of nitrogenous manures.

*Failure of continuous clover-cropping on ordinary arable land.*

To conclude in regard to these experiments: The attempt to grow clover year after year on this ordinary arable land, by means of such mineral manures as increase the luxuriance of growth when there is a fair plant, or even by the addition to these of nitrogenous manures, has entirely failed. In view of this failure to grow the crop continuously on ordinary arable land, the next results to which we have to call attention are of much interest and significance.

### *Growth of Red Clover, year after year, on rich Garden Soil.*

*Success of continuous clover-cropping on garden soil.*

In 1854, after it seemed clear that the plant would not continue to grow on the arable land, clover was sown in a garden only a few hundred yards distant from the experimental field, on soil which had been under ordinary kitchen-garden cultivation for probably two or three centuries. It is remarkable that, under these conditions, the crop has grown luxuriantly almost every year since—1893 being the fortieth season of the continuous growth. Further particulars will be given on the point presently, but it may here be premised that, at the commencement, the percentage of nitrogen in the surface-soil of the garden was four or five times as high as in that of the arable soil in the field; and it would doubtless be richer in all other manurial constituents also. Indeed, after the growth of clover for 25 years in succession, even the second 9 inches of depth was found to be still very much richer in nitrogen than the first 9 inches in the field.

*Condition of the garden soil.*

*Table 38 explained.*

Table 38 gives the results for each of the 40 years of experiment with clover on the rich garden-soil. The first column after the dates shows the number of cuttings each year, the second the amounts of produce per acre, reckoned in the condition of dryness as hay, the third the amount of dry substance, the fourth that of the mineral matter, and the last the estimated amounts of nitrogen per acre in the crops. At the bottom of the table are given the average annual results, over periods of 10, 10, 10, 10, and 40 years. It

TABLE 38.—RED CLOVER. Grown year after year on rich Garden Soil. 40 years, 1854-93. Hay, Dry Matter, Mineral Matter, and Nitrogen, per acre per annum.

| | Number of cuttings. | As hay. | Dry matter. | Mineral matter. | Nitrogen (estimated). | Seed sown. |
|---|---|---|---|---|---|---|
| | | lb. | lb. | lb. | lb. | |
| 1854 | 2 | 5,191 | 4,326 | 435 | 125 | 1854, March. |
| 1855 | 3 | 18,113 | 15,094 | 1560 | 435 | ... |
| 1856 | 2 | 11,027 | 9,190 | 1116 | 265 | ... |
| 1857 | 3 | 14,855 | 12,379 | 1384 | 357 | ... |
| 1858 | 2 | 7,608 | 6,340 | 792 | 183 | ... |
| 1859 | 2 | 6,227 | 5,189 | 687 | 149 | ... |
| 1860 | 1 | 8,679 | 7,233 | 806 | 208 | 1860, May. |
| 1861 | 2 | 13,353 | 11,128 | 1285 | 321 | ... |
| 1862 | 2 | 10,042 | 8,368 | 991 | 241 | ... |
| 1863 | 2 | 11,798 | 9,832 | 971 | 283 | |
| 1864 | 2 | 5,500 | 4,583 | 446 | 132 | ... |
| 1865 | 1 | 2,044 | 1,704 | 190 | 49 | 1865, April. |
| 1866 | 2 | 10,456 | 8,713 | 908 | 251 | ... |
| 1867 | 2 | 6,748 | 5,624 | 573 | 162 | ... |
| 1868 | 1 | 991 | 826 | 106 | 24 | 1868, April. |
| 1869 | 2 | 4,183 | 3,486 | 387 | 100 | ... |
| 1870 | 1 | 1,741 | 1,451 | 148 | 42 | ... |
| 1871 | 1 | 4,513 | 3,761 | 458 | 108 | 1871, April. |
| 1872 | 2 | 10,142 | 8,452 | 899 | 243 | ... |
| 1873 | 2 | 9,287 | 7,740 | 772 | 223 | ... |
| 1874 | 3 | 5,899 | 4,916 | 540 | 142 | 1874, May and July. |
| 1875 | 1 | 2,731 | 2,276 | 230 | 66 | 1875, July and September. |
| 1876 | 2 | 3,517 | 2,931 | 279 | 84 | 1876, September. |
| 1877 | 1 | 3,533 | 2,944 | 326 | 85 | 1877, May. |
| 1878 | 3 | 13,416 | 11,180 | 1336 | 322 | ... |
| 1879 | 1 | 2,738 | 2,282 | 428 | 66 | 1879, May. |
| 1880 | 2 | 5,742 | 4,785 | 643 | 138 | 1880, April. |
| 1881 | 2 | 4,262 | 3,552 | 330 | 102 | 1881, April (mended). |
| 1882 | 3 | 6,433 | 5,361 | 641 | 154 | 1882, April (mended). |
| 1883 | 1 | 2,716 | 2,264 | 315 | 65 | 1883, May. |
| 1884 | 3 | 9,990 | 8,325 | 863 | 240 | ... |
| 1885 | 3 | 6,511 | 5,426 | 615 | 156 | ... |
| 1886 | 1 | 2,702 | 2,252 | 313 | 65 | 1886, April. |
| 1887 | 2 | 3,287 | 2,739 | 264 | 79 | 1887, April (mended). |
| 1888 | 1 | 1,841 | 1,535 | 211 | 44 | 1888, April (mended June). |
| 1889 | 2 | 8,664 | 7,221 | 754 | 208 | 1889, April (mended). |
| 1890 | 1 | 2,817 | 2,348 | 367 | 68 | 1890, April. |
| 1891 | 2 | 6,696 | 5,580 | 574 | 161 | 1891, May (mended). |
| 1892 | 1 | 3,568 | 2,973 | 355 | 86 | 1892, May 7 (May 27, mended). |
| 1893 | 2 | 5,941 | 4,951 | 500 | 143 | 1893, April (mended). |

AVERAGE PER ACRE PER ANNUM.

| | Number of cuttings. | As hay. | Dry matter. | Mineral matter. | Nitrogen (estimated). | Seed sown. |
|---|---|---|---|---|---|---|
| 10 years, 1854-63 | | 10,689 | 8,908 | 1003 | 257 | ... |
| " " 1864-73 | | 5,561 | 4,634 | 489 | 133 | ... |
| " " 1874-83 | | 5,099 | 4,249 | 507 | 122 | ... |
| " " 1884-93 | | 5,202 | 4,335 | 482 | 125 | ... |
| 40 " 1854-93 | ... | 6,638 | 5,532 | 620 | 159 | ... |

should be stated that, as the garden clover plot is only a few yards square, calculations of produce per acre can only give approximations to the truth; but it is believed that they can be thoroughly relied upon so far as their general indications are concerned. It may be added that five times during the whole period, gypsum has been applied to one-third, and a mineral manure containing potash, but no nitrogen, to another third of this plot.

*Produce of the continuously grown clover.*

We shall confine attention to the amounts of produce reckoned as hay, and to the estimated amounts of nitrogen in the produce. Casting the eye down the column of produce as hay, it is seen at a glance that, excepting a few occasional years of very high produce during the later periods, the amount of crop is very much greater during the first than during either of the subsequent periods of 10 years. In fact, as is seen at the foot of the table, there was an average annual produce equal to 10,689 lb. of hay over the first period of 10 years, but of only 5561 lb. over the second, 5099 lb. over the third, and 5202 lb. over the last 10 years.

Now, even these latter amounts correspond to what would be considered fair though not large crops, when clover is grown in an ordinary course of rotation, once only in 4, or in 8 years, or more; so that the produce in the earlier years on this rich garden-soil was very unusually heavy. Indeed the average annual produce over the whole period of 40 years—namely, 6638 lb., or nearly 3 tons of hay—would be a very good yield for the crop grown only occasionally in the ordinary course of agriculture.

*Amount of nitrogen in the continuously grown clover crop.*

But it is when we look at the figures in the last column of the table, which show the estimated amounts of nitrogen in the crops, that the importance and significance of these results obtained on rich garden-soil are fully recognised; and this is especially the case when they are compared with those obtained on ordinary arable land.

Thus the amount of nitrogen in fair crops of wheat, barley, or oats, will be from 40 to 50 lb. per acre; of beans about 100 lb.; of meadow-hay about 50 lb; and of clover grown occasionally in rotation from 100 to 150 lb.; but here, on this rich garden-soil, the produce of clover has in one year contained more than 400 lb. of nitrogen, in three years more than 300 lb., in several more than 200 lb., and in only thirteen years of the 40 less than 100 lb.

In fact, as the figures at the bottom of the table show, the estimated average annual yield of nitrogen in the above-ground growth was—over the first 10 years 257 lb., over the second 10 years 133 lb., over the third 10 years 122 lb., over the last 10 years 125 lb., and over the whole period of 40

years 159 lb; whilst, as the details show, the yield of nitrogen in the thirty-first year (1884) was about 240 lb., in the thirty-second year 156 lb., in the thirty-sixth year 208 lb., in the thirty-eighth year 161 lb., and in the fortieth 143 lb. Further, the averages over the second, third, and fourth, 10 years of the continuous growth (133, 122, and 125 lb.) were about as much as in a fair but not large crop grown occasionally under the ordinary conditions of agriculture; whilst the average of the 40 years, 159 lb., is as much as in a really good crop grown occasionally in rotation.

*Condition of soil the ruling influence.*

There would seem, then, to be clearly indicated, a *soil-source* of failure on the arable land, and a *soil-source* of success on the garden-soil.

The results given in Table 39 will throw some further light on this point. It shows the percentage of nitrogen in the first 9 inches of depth of the garden-soil, in 1857 and in 1879, between which periods the growth of 21 years had been removed. It also shows the estimated amounts of nitrogen per acre in the surface-soil at the two periods, and the reduction in the amount during the 21 years.

TABLE 39.—RED CLOVER, grown on rich Garden-Soil. Nitrogen per cent, and per acre, in the fine soil, dried at 100° C. (First 9 inches of depth.)

| | 1857. | 1879. | Difference. |
|---|---|---|---|
| | per cent. 0.5095 | per cent. 0.3634 | per cent. 0.1461 |
| | lb. | lb. | lb. |
| Per acre, . . . . . Total | 9528 | 6796 | 2732 |
| Per acre per annum (21 years) . | ... | ... | 130 |

It may be mentioned that the percentage of nitrogen given for the sample collected in October 1857, is the mean of duplicate or more determinations, made in 1857, in 1866, and again in 1880; and it is almost identical with the results obtained at the latest of these dates.

*Richness of the garden soil in nitrogen.*

The first point to notice is that the first 9 inches of depth of this rich garden-soil contained more than half a per cent of nitrogen—that is, nearly four times as much as the average of the Rothamsted arable soils, and nearly five times as much as the exhausted arable clover-land-soil where the crop failed. It is, of course, true that the garden-soil would be correspondingly rich in all other constituents; but some portions of the arable soil where the clover failed, had received much more of mineral constituents by manure than had been removed in the crops.

The result given for 1879 is the mean of determinations

*Reduction in nitrogen in garden soil under clover.*

made on three separate samples, for which the determinations agreed very well. The results can leave no doubt that there had been a great reduction in the stock of nitrogen in the surface-soil since 1857. The reduction amounts to nearly 29 per cent of the whole in the 21 years; and, reckoned per acre, it corresponded, as shown in the table, to a loss of 2732 lb. during the 21 years; and although, as has been seen, fairly average, and even good crops, were still grown, it is obvious that coincidentally with this great reduction in the stock of nitrogen in the surface-soil, there has been a very marked reduction in the clover-growing capability of the soil.

*Reduced persistence and reduced produce of the clover.*

On this point it may be mentioned that, whilst fresh seed was only sown five times during the first 20 of the 40 years, it has been fully or partially sown twenty-one times during the last 20 years. It is obvious, therefore, that the plant was able to stand very much longer in the earlier than in the later condition of the soil. Indeed, both the reduced persistence of the plant, and the reduced produce, have been coincident with a considerable reduction in the stock of nitrogen in the soil.

The question arises, What relation does the amount of nitrogen lost by the soil bear to the amount taken off in the crops?

*Amounts of nitrogen removed in the crop and lost by the soil.*

It is admittedly necessary to accept with some reservation results of calculations of produce per acre from amounts obtained on a few square yards, but the general indications may doubtless be trusted. Such estimates show more than 160 lb. of nitrogen to have been removed per acre per annum in the crops over the 21 years; whilst the estimated loss of the surface-soil corresponds to about 130 lb. per acre per annum. That is to say, the loss by the surface-soil is sufficient to account for a large proportion of the nitrogen removed in the crops.

There is, however, evidence leading to the conclusion that, when excessive amounts of farmyard manure have been applied, as had been the case with this garden-soil, there may be some loss by the evolution of free nitrogen; and obviously, so far as this may have occurred, there will be the less of the ascertained loss to be credited to assimilation by the growing clover.

*Clover drawing upon subsoil.*

On the other hand, it is known that when growing on ordinary arable soil, the clover plant throws out a large amount of feeding roots in the lower layers; and although in the case of so rich a surface-soil the plant may derive a larger proportion of its nutriment from that source, we must at the same time suppose that it has also availed itself of the resources of the subsoil. Unfortunately, in 1857 samples

were only taken to a depth of 9 inches, so that no comparison can be made of the condition of the subsoil at the two periods. In 1879, however, the second 9 inches of the garden-soil was found to contain a much higher percentage of nitrogen than the first 9 inches of the clover-exhausted arable field, and about three times as high a percentage as the subsoil of the arable field at the same depth. It cannot be doubted, therefore, that the subsoil of the garden plot has contributed nitrogen to the clover crops.

*Soil-source of nitrogen for clover.*

Here, then, notwithstanding the very little effect of direct nitrogenous manures on either the beans or the clover growing on the ordinary arable land, there would seem to be very clear evidence of a soil-source of, at any rate much of the enormous amounts of nitrogen assimilated over a given area by the clover growing on the rich garden-soil.

It may here be observed that, in experiments on the mixed herbage of permanent grass-land, in which the growth of leguminous herbage was much increased by the application of mineral manure containing potash, it was found at the end of 20 years that the amount of nitrogen in the surface-soil had been considerably reduced, compared with that of a plot which had been unmanured, and had yielded very much less leguminous herbage. The conclusion was that, as in the case of the clover growing on the rich garden-soil, the nitrogen of the surface-soil had been a source of, at any rate much of the nitrogen of the increased produce of Leguminosæ in the mixed herbage of the grass-land.

### *Red Clover grown after the Beans.*

After the cessation of the experiment with *beans* in 1878, the land was left fallow for between four and five years, to 1882 inclusive, when grass-seeds were sown, but failed. On this land, on which the attempt to grow the leguminous crop, beans, year after year had failed, and been abandoned, barley and clover were sown in the spring of 1883.

*Exhaustion of nitrogen by beans.*

In April 1883, however, before the barley and clover were sown, the surface-soil (free of stones, and reckoned dry) of the plot, which had been entirely unmanured during the 32 years of the experiments with the beans, was found to contain 0.0993 per cent of nitrogen, that of the mineral-manured plot 0.1087 per cent, and that of the plot which had received both the mineral and nitrogenous manure 0.1163 per cent—amounts which show considerable nitrogen exhaustion of the surface-soil.

Also in 1883, the nitrogen as nitric acid was determined in samples, each of 9 inches of depth, down to a total depth of

72 inches. In the case of several plots the results show, calculated per acre, that the total amount of nitrogen as nitric acid to the depth of eight times 9 inches, or 72 inches in all, was 27.95 lb. in the unmanured plot, 20.72 lb. in that with purely mineral manure, and 25.38 lb. in that of the plot which had received both mineral and nitrogenous manure. In the soil of the farmyard manure plot, on the other hand, the amount was about twice as much—namely, 50.46 lb. Excluding this last result, it may be said that the amounts of nitrogen already existing as nitric acid, to the depth determined, were very small.

These, then, were the conditions of the soil when the barley and clover were sown in the spring of 1883. The clover grew very luxuriantly from the first, so much so as to considerably interfere with the growth of the barley.

Table 40 shows the amounts of nitrogen per acre in the barley and clover in 1883, and in the clover in 1884 and 1885.

TABLE 40.—BARLEY AND CLOVER, GROWN AFTER BEANS, GEESCROFT FIELD. Nitrogen removed per acre in the crops.

| Previous condition of manuring | 1883. Barley and clover. | 1884. Clover. | 1885. Clover. | Total |
|---|---|---|---|---|
| | lb | lb. | lb. | lb |
| Without manure . . . | 45.0 | 183.2 | 52.7 | 280.9 |
| Mineral manure and some nitrogen | 57.2 | 193.1 | 79.9 | 330.2 |
| Mineral manure only . . | 59.3 | 206.4 | 81.6 | 347.3 |

*Table* 40 *explained.* It should be stated that the plots, the yield of nitrogen of which is here given, do not exactly correspond with those for which the yield of nitrogen in the beans was given; some of the barley and clover crops having been taken together where no difference in the produce was observable. Thus, half the plot represented as without manure had been unmanured from the commencement—that is, for nearly 40 years, but the other half received some nitrogen to 1878 inclusive, but had since been entirely unmanured. Again, the results given in the second line relate to the produce of a plot part of which received purely mineral manure, but the other part ammonium-salts or nitrate up to 1878, but none since. The results given in the third line relate, however, to a plot which has not received any nitrogenous manure from the commencement of the experiments with the beans, but which was not brought under experiment until 5 years later than the other plots.

Thus, on a plot where a purely mineral manure containing potash, but no nitrogen, had been applied for 27 years, to

1878 inclusive, and no manure since, 347.3 lb. of nitrogen were gathered per acre, almost wholly by the leguminous crop—clover. On a plot on part of which the mineral manure only, and on part the same mineral manure and ammonium-salts or nitrate had been applied up to 1878, but nothing since, 330.2 lb. of nitrogen were removed in the crops. Lastly, where to half of the plot no manure whatever had been applied for nearly 40 years, but to the other half ammonium-salts or nitrate up to 1878, the yield of nitrogen in the barley and clover was 280.9 lb.

*Yield of nitrogen.*

Here, then, in a field where beans had been grown for many years in succession, and had yielded much less than average crops, and the land had then been left fallow for several years; where the surface-soil had become very poor in total nitrogen; where both surface and subsoil were very poor in ready-formed nitric acid; and where there was a minimum amount of crop-residue near the surface for decomposition and nitrification; there were grown very large crops of clover, containing very large amounts of nitrogen.

*Large clover crops from soil poor in nitrogen.*

Not only was so much nitrogen removed in the crops, but the surface-soils became determinably richer in nitrogen as the results in Table 41 show. There are there given the percentages of nitrogen in the sifted dry surface-soil of the three plots for which the produce and the nitrogen in the beans have been given. The results relate to samples taken in April 1883, before the sowing of the barley and clover, and in November 1885, after the removal of the crops. The first two columns show the percentages of nitrogen, and the other columns the calculated amounts of it per acre, in the surface-soils, 9 inches deep, at the different dates; also the estimated gain of nitrogen under the influence of the growth of the clover.

*The soil enriched in nitrogen by the clover.*

TABLE 41.—NITROGEN, PER CENT, AND PER ACRE, IN THE SURFACE-SOILS, BEFORE AND AFTER THE GROWTH OF THE BARLEY AND CLOVER.

| | Nitrogen in sifted dry soil. | | | | |
|---|---|---|---|---|---|
| | Per cent. | | Per acre. | | |
| | 1883. | 1885. | 1883 | 1885. | 1885 + or − 1883. |
| | per cent. | per cent. | lb. | lb. | lb. |
| 1. Without manure | 0.0993 | 0.1083 | 2441 | 2662 | +221 |
| 2. With mineral manure containing potash | 0.1087 | 0.1149 | 2672 | 2824 | +152 |
| 3. With mineral manure and nitrogen | 0.1163 | 0.1225 | 2859 | 3011 | +152 |

*Large accumulation of nitrogen—where did it come from?*

Without assuming that the figures represent accurately the amounts of nitrogen accumulated per acre, it cannot be doubted that the surface-soils had become considerably richer. If, for the sake of illustration, we assume that 300 lb. of nitrogen were removed per acre in the crop, and that 150 lb. were accumulated in the surface-soil, we have 450 lb. of nitrogen to account for, as gathered by the crops within a period of little more than two years.

It is clear that we have in the experimental results themselves no conclusive evidence as to the source of so large an amount of nitrogen. As the surface-soil became determinably richer, it is obvious that it must have been derived either from above or below it—from the atmosphere or from the subsoil; and, if from the subsoil, the question arises, whether it was taken up as nitric acid, as ammonia, or as organic nitrogen? Results relating to these points will be referred to presently; but it must be admitted that there is nothing in the experimental results themselves to show that so large an amount of nitrogen could have been available as nitric acid. There remains the question whether the free nitrogen of the atmosphere has in any way been brought into combination, either within the soil or within the plants? Evidence on these points will be adduced further on.

### *Various Leguminous Plants grown after Red Clover.*

We have now to adduce another and even much more striking instance of successful growth, and of great accumulation of nitrogen, by plants of the leguminous Order, on soil where another plant of the same order had failed, and where the surface-soil had become very poor in nitrogen.

The experiments were made on the plots where it had been attempted to grow red clover year after year on ordinary arable land; where, in fact, clover had been sown twelve times in 30 years, and where, in eight out of the last ten trials, the plant had died off in the winter and spring succeeding the sowing of the seed—in four cases without any crop at all, and in the other four yielding very small cuttings.

In 1878, the land was devoted to experiments with various leguminous plants, differently manured, having regard, however, to the previous manurial history of the plots.

*Object of the experiment.*

The object was to ascertain whether, among a selection of plants all belonging to the leguminous Order, but of different habits of growth, and especially of different character and range of roots, some could be grown successfully for a longer time, and would yield more produce, containing more nitrogen, as well as other constituents, than others; all being supplied

with the same descriptions and quantities of manuring substances, applied to the surface-soil. Further, whether the success in some cases, and the failure in others, would afford additional evidence as to the source of the nitrogen of the Leguminosæ generally, and as to the causes of the failure of red clover when grown too frequently on the same land.

*Crops selected for trial.* Accordingly, fourteen different Leguminosæ were selected, and sown in 1878. These included eight species or varieties of *Trifolium*, two species of *Medicago*, *Melilotus leucantha*, *Lotus corniculatus*, *Vicia sativa*, and *Lathyrus pratensis*. Of these, six of the eight *Trifoliums* have already failed, and been replaced by other plants; as also have the *Medicago lupilina*, the *Lotus corniculatus*, and the *Lathyrus pratensis*, the last being replaced in the second year by *Onobrychis sativa*. The plants which have maintained fair, but very varying, character of growth, are the *Trifolium repens*, *Vicia sativa*, *Melilotus leucantha*, and *Medicago sativa*; and we propose to give some account of the growth of these plants on the clover-exhausted soil.

*Soil poor in nitrogen.* That the surface-soil had become very poor in nitrogen is evident from the fact that the mean percentage of it in the sifted dry surface-soil of five of the clover plots was, in March 1881, only 0.1058, which is considerably lower than was found in the same field many years before; and lower than has been found in any of the fields at Rothamsted, excepting those where crops have been grown for many years on the same land without nitrogenous manure. It is a point of interest, however, that the percentage in the surface-soil was not so low as in immediately adjoining land, which had been under alternate wheat and fallow for nearly 30 years without manure.

*The points of interest.* The real interest of the results depends on the amounts, and on the difference in the amounts, of nitrogen which the various plants have assimilated over a given area, all growing side by side on the same red clover-exhausted land, and with the same mineral manures, without any supply of nitrogen.

*Table 42 explained.* Accordingly, the upper part of Table 42 (p. 128) shows the estimated average amounts of nitrogen in the gramineous crop—wheat, grown in alternation with fallow, over 27 years to 1877 inclusive, and in the red clover (together with other crops when it failed) over 29 years, also to 1877 inclusive. Then, in the body of the table are given the amounts of nitrogen in the wheat alternated with fallow, and in the produce of five different leguminous plants during the subsequent years, commencing with 1878, and extending in some cases to 1891.

Thus, over the preliminary period, the wheat gave an

average annual yield of nitrogen per acre of 15 lb., and the clover gave, over much the same period, an average of 32 lb. of nitrogen.

TABLE 42.—Estimated yield of Nitrogen per acre, in lb., in Wheat alternated with Fallow, and in various Leguminous Crops without Nitrogenous Manure.

| | Unmanured | Mineral manures only | | | | |
|---|---|---|---|---|---|---|
| | Fallow wheat | *Trifolium pratense* | *Trifolium repens.* | *Vicia sativa* | *Melilotus leucantha* | *Medicago sativa* |
| **PRELIMINARY PERIOD—Wheat and Fallow, 27 years, 1851-77; Red Clover, &c., 29 years, 1849-77.** | | | | | | |
| | lb. | lb | | | | |
| Average per acre per annum | 15 | 32 | | | | |
| **EXPERIMENTAL PERIOD.** | | | | | | |
| | lb | lb | lb | lb | lb | lb |
| 1878 | 14 | 0 | 0 | 51 | 53 | 0 |
| 1879 | 5 | 50 | 82 | 46 | 130 | 0 |
| 1880 | 12 | 8 | 0 | 58 | 36 | 28 |
| 1881 | 9 | 21 | 8 | 65 | 60 | 28 |
| 1882 | 9 | 18 | 74 | 146 | 115 | 111 |
| 1883 | 13 | 0 | 0 | 101 | 27 | 143 |
| 1884 | 15 | 0 | 0 | 113 | 56 | 337 |
| 1885 | 16 | 15 | 97 | 90 | 58 | 270 |
| 1886 | 7 | Lupins | 16 | 52 | 0 | 167 |
| 1887 | 13 | 0 | 6 | 64 | 82 | 247 |
| 1888 | 9 | *Medicago sativa* | 0 | 60 | 32 | 161 |
| 1889 | 9 | | 0 | 65 | 23 | 153 |
| 1890 | 14 | | Fallow | 61 | *Trifolium pratense* | 124 |
| 1891 | 18 | | *Faba vulg* | 79 | | 147 |
| Total, 14 years, 1878-91 | 163 | 112[1] | 283[2] | 1051 | 702[2] | 1916 |
| Average, 14 years, 1878-91 | 12 | 14[1] | 24[2] | 75 | 58[2] | 137 |
| Average for years of crop | 12 | 22 | 47 | 75 | 61 | 160 |

[1] 8 years only, 1878-85. [2] 12 years only, 1878-89.

*Yield of nitrogen by the various crops.*

Against these amounts the various crops yielded, over the subsequent years, averages per acre per annum as follows: The fallow-wheat, over 14 years 12 lb.; the red clover (*Trifolium pratense*), over 8 years 14 lb.; the white clover (*Trifolium repens*), over 12 years 24 lb.; the vetch (*Vicia sativa*), over 14 years 75 lb.; the Bokhara clover (*Melilotus leucantha*), over 12 years 58 lb.; and the lucerne (*Medicago sativa*), over 12 years 137 lb.

Or if we take the average amounts over the years of actual crop only, they were—in the wheat 12 lb., in the red

clover 22 lb., in the white clover 47 lb., in the vetch 75 lb., in the Bokhara clover 64 lb., and in the lucerne the enormous amount of 160 lb., of nitrogen per acre per annum.

Again, if we take the total yields of nitrogen over the experimental periods, we have—in the wheat 163 lb., in the red clover 112 lb., in the white clover 283 lb., in the vetch 1051 lb., in the Bokhara clover 702 lb., and in the lucerne 1916 lb.; that is, in the lucerne about twelve times as much as in the wheat, nearly twice as much as in the vetch, and very much more than in either of the other Leguminosæ. Indeed, this very deeply and very powerfully rooting-plant yielded, in its above-ground produce alone, 337 lb. of nitrogen in 1884, 270 lb. in 1885, 167 lb. in 1886, 247 lb. in 1887, and an average of 146 lb. over the next four years.

*Soil enriched in nitrogen.*

Not only have these large amounts of nitrogen been removed in the above-ground produce, but determinations of nitrogen in the soils of the vetch plot in 1883, and of the white clover, the Bokhara clover, and the lucerne plots, in 1885, have shown, as in the case of the clover after the beans, that the surface-soil had gained rather than lost nitrogen, due to the accumulation of nitrogenous crop-residue. Here again, then, it is obvious that the original source of the nitrogen of the crops has not been the surface-soil itself. It must have been derived either from the atmosphere or from the subsoil.

*Nitrogen from the subsoil or the atmosphere.*

The next results will throw some light on this point. Thus, having made initiative experiments of the same kind some years previously, in July 1883 samples of soil were taken to the depth of twelve times 9 inches, or 108 inches in all, on the wheat-fallow plot, on the white clover plot, and on two of the vetch plots, for the determination of the amount of nitrogen existing as nitric acid at each depth. Table 43 (p. 130) summarises the results.

The first point to notice is that at each depth, from the first to the twelfth, the *Trifolium repens* soil contained much more nitrogen as nitric acid than the wheat-fallow soil; and as the figures at the bottom of the table show, whilst to the total depth of 108 inches, or 9 feet, the wheat-fallow soil was estimated to contain only 52.4 lb. of nitrogen as nitric acid per acre, the *Trifolium repens* soil—that is, the leguminous plant soil—contained to the same depth 145.7 lb.

*Nitrogen in soil after leguminous crops.*

Now, independently of the fact that the leguminous plant plots had received mineral manures and the wheat-land had not, the characteristic difference in the history of the two plots was, that the one had from time to time grown a leguminous crop, and the other had not; and the one which had grown leguminous crops contained, to the depth of 9 feet,

nearly three times as much nitrogen as nitric acid as the gramineous crop soil.

TABLE 43.—NITROGEN AS NITRIC ACID PER ACRE, LB., IN SOILS OF SOME EXPERIMENTAL PLOTS, WITHOUT NITROGENOUS MANURE FOR MORE THAN 30 YEARS; HOOSFIELD, ROTHAMSTED. Samples collected July 17-26, 1883.

| Depths. | Wheat-fallow land unmanured. | *Trifolium repens*, Series 1, Plot 4. | *Vicia sativa*, Series 1, Plot 4. | *Vicia sativa*, Series 1, Plot 6. | *Trifolium repens*, + or − Wheat-land. | + or − *Trifolium repens*. | |
|---|---|---|---|---|---|---|---|
| | | | | | | *Vicia sativa*, Plot 4. | *Vicia sativa*, Plot 6. |
| Inches. | lb. | lb. | lb. | lb | lb. | lb. | lb. |
| 1-9 | 19.85 | 30.90 | 12.16 | 10.22 | +11.05 | −18.74 | −20.68 |
| 10-18 | 8.05 | 27.73 | 4.11 | 2.72 | +19.68 | −23.62 | −25.01 |
| 19-27 | 2.47 | 8.44 | 1.37 | 1.08 | + 5.97 | − 7.07 | − 7.36 |
| 28-36 | 2.70 | 7.64 | 1.67 | 1.52 | + 4.94 | − 5.97 | − 6.12 |
| 37-45 | 1.62 | 9.07 | 4.58 | 2.51 | + 7.45 | − 4.49 | − 6.56 |
| 46-54 | 3.57 | 8.77 | 6.37 | 4.42 | + 5.20 | − 2.40 | − 4.35 |
| 55-63 | 3.84 | 7.92 | 7.16 | 4.52 | + 4.08 | − 0.76 | − 3.40 |
| 64-72 | 2.28 | 8.34 | 5.95 | 4.92 | + 6.06 | − 2.39 | − 3.42 |
| 73-81 | 1.48 | 8.27 | 4.54 | 4.81 | + 6.79 | − 3.73 | − 3.46 |
| 82-90 | 1.76 | 9.95 | 5.32 | 5.14 | + 8.19 | − 4.63 | − 4.81 |
| 91-99 | 2.94 | 9.16 | 5.66 | 6.40 | + 6.22 | − 3.50 | − 2.76 |
| 100-108 | 1.84 | 9.51 | 5.32 | 6.46 | + 7.67 | − 4.19 | − 3.05 |
| SUMMARY. | | | | | | | |
| 1-27 | 30.37 | 67.07 | 17.64 | 14.02 | +36.70 | −49.43 | −53.05 |
| 28-54 | 7.89 | 25.48 | 12.62 | 8.45 | +17.59 | −12.86 | −17.03 |
| 55-81 | 7.60 | 24.53 | 17.65 | 14.25 | +16.93 | − 6.88 | −10.28 |
| 82-108 | 6.54 | 28.62 | 16.30 | 18.00 | +22.08 | −12.32 | −10.62 |
| 1-54 | 38.26 | 92.55 | 30.26 | 22.47 | +54.29 | −62.29 | −70.08 |
| 55-108 | 14.14 | 53.15 | 33.95 | 32.25 | +39.01 | −19.20 | −20.90 |
| 1-108 | 52.40 | 145.70 | 64.21 | 54.72 | +93.30 | −81.49 | −90.98 |

The difference is the greatest near the surface, but it is very considerable down to the lowest depths. In the first three depths there was more than twice as much nitrogen as nitric acid in the *Trifolium repens*, as in the wheat-fallow soil; in the second and third three depths, there was more than three times; and in the fourth, three more than four times as much. Hence it is obvious, that any loss by drainage would be much the greater from the *Trifolium* plot, so that the difference between the two plots was probably greater than the figures show.

*Nitrification and soil nitrogen.*

In the case of both plots, the actual amount of nitrogen as nitric acid was the greatest near the surface, indicating more active nitrification; and the greater amount in the *Trifolium*

soil is doubtless due to more nitrogenous crop-residue from the leguminous than from the gramineous crop. Indeed, about 74 lb. per acre of nitrogen had been removed in the *Trifolium repens* crops, and only 18 lb. in the wheat (reckoned on the half-acre in crop) in 1882, and none from either in 1883, the year of soil-sampling; and the crop-residue of the *Trifolium repens* would contain much more nitrogen than that of the wheat. But it is not probable that the excess of nitric acid in the *Trifolium* soil, together with the larger amount lost by drainage, could be entirely due to the nitrification of recent crop-residue. Some found in the lower layers was, however, doubtless due to washing down from the surface. But, as notwithstanding much more nitrogen had been removed in the crops from the leguminous than from the gramineous crop-land during the preceding 30 years, the surface-soil of the leguminous plot remained slightly richer in nitrogen, it is obvious that the whole of the nitrogen of the nitric acid could not have had its origin in the surface-soil. If, therefore, it did not come from the atmosphere, it has been derived from the subsoil. *Again, where did the nitrogen come from?*

*Nitrification active after leguminous growth.* The indication is, that nitrification is more active under the influence of leguminous than of gramineous growth and crop-residue. There would not only be more nitrogenous matter for nitrification, but it would seem that the development of the nitrifying organisms is the more favoured. Part of the result may, therefore, be due to the passage downwards of the organisms, and the nitrification of the organic nitrogen of the subsoil.

*An alternative.* An alternative is, that the soil and the subsoil may still be the source of the nitrogen, but that the plants may take up, at any rate part, as ammonia or as organic nitrogen. To this point we shall recur presently.

*Results with vetches.* Comparing the amounts of nitrogen as nitric acid in the *Vicia sativa* soils with those in the *Trifolium repens* soil, it is to be observed that, whilst from the *Trifolium repens* soil only 164 lb. of nitrogen had been removed per acre in the crops of the five years to 1882 inclusive, 366 lb. had been removed in the *Vicia* crops to the same date. Then, whilst none was removed in crops from the *Trifolium* plot in 1883, 101 lb. were removed in the *Vicia* crops just before soil-sampling. Under these circumstances one of the *Vicia* soils contained 81.5 lb., and the other 91 lb., less nitrogen as nitric acid per acre than the *Trifolium repens* soil.

Of course we cannot know exactly how much was at the disposal of the plants at the commencement of growth; but if there had only been as much as in the case of the *Trifolium* plot, it is seen that the deficiency in the *Vicia* soils

nearly corresponds with the amount removed in the crop, which was 101 lb. It may at any rate safely be concluded that most, if not the whole, of the nitrogen of the *Vicia* crops, had been taken up as nitric acid.

But, as the *Vicia* crops had removed much more in the preceding years than the *Trifolium* crops, so also would their crop-residue be greater; and in fact much more nitrogen must have been taken up by the plants each year than the figures show — and the larger the crop-residue, the larger would be the amount of nitric acid for each succeeding crop. But the crop of 1883 was also large, and it would leave a correspondingly large nitrogenous crop-residue; leaving, therefore, a large amount of the nitrogen assimilated to be otherwise accounted for than by previous crop-residue.

Lastly in reference to these experiments, it is seen that at each of the twelve depths, the *Vicia* soils with growth, contained much less nitric acid than the *Trifolium* soil without growth; and the difference is much the greatest in the upper four or five depths, within which the *Vicia* throws out by far the larger proportion of its feeding roots; but the deficiency is quite distinct below this depth. The supposition is that, under the influence of the growth, water had been brought up from below, and with it nitric acid. In fact, determinations showed that, down to the depth of 108 inches, the *Vicia* soils contained less water than the *Trifolium* soil, in amount corresponding to between 6 and 7 inches of rain, or to between 600 and 700 tons of water per acre.

*Further experiments.* Experiments of the same kind were again made in 1885. *Trifolium repens* was again selected as the weak and superficially rooting plant, *Melilotus leucantha* as a deeper and stronger rooting one, and the *Medicago sativa* as a still deeper and still stronger rooting plant. Samples of soil were taken at the end of July and the beginning of August, from two places on each plot, and in each case as before, to twelve depths of 9 inches each, or to a total depth of 108 inches, or 9 feet. It will suffice to quote the results for the *Trifolium repens* and the *Medicago sativa* plots. They are given in Table 44.

It is seen that there was much less nitrogen as nitric acid in the *Trifolium repens* soil in 1885, after the removal of 97 lb. in the crops, than in 1883 (see Table 43, p. 130), when there had been no crop. The deficiency is the greatest in the two upper layers; but it extends to the fifth depth, representing the range of the direct and indirect action of the superficial roots. Below this point there is, however, even more than in 1883; due, doubtless, in part to percolation from above during the two preceding seasons without growth,

and possibly in part to percolation of the nitrifying organisms, and the nitrification of the nitrogen of the sub-soil.

Let us now compare the results relating to the *Medicago sativa* with those relating to the *Trifolium repens* soils.

TABLE 44.—NITROGEN AS NITRIC ACID PER ACRE, LB., IN THE SOIL AND SUBSOILS OF SOME EXPERIMENTAL PLOTS, WITHOUT NITROGENOUS MANURE FOR MORE THAN 30 YEARS; HOOSFIELD, ROTHAMSTED. Samples collected July 29 to August 14, 1885.

| Depths. | Series 1. Mineral manures. | | |
|---|---|---|---|
| | *Trifolium repens,* Plot 5. | *Medicago sativa,* Plot 5. | *Medicago sativa,* + or − *Trifolium repens.* |
| Inches. | lb. | lb. | lb. |
| 1-9 | 11.50 | 8.88 | − 2.62 |
| 10-18 | 1.38 | 1.11 | − 0.27 |
| 19-27 | 0.90 | 0.78 | − 0.12 |
| 28-36 | 1.86 | 0.81 | − 1.05 |
| 37-45 | 7.08 | 0.99 | − 6.09 |
| 46-54 | 11.31 | 0.93 | −10.38 |
| 55-63 | 13.14 | 0.57 | −12.57 |
| 64-72 | 12.63 | 0.81 | −11.82 |
| 73-81 | 11.19 | 0.70 | −10.49 |
| 82-90 | 10.70 | 0.61 | −10.09 |
| 91-99 | 11.08 | 0.44 | −10.64 |
| 100-108 | 9.96 | 0.41 | − 9.55 |
| Total . | 102.73 | 17.04 | −85.69 |

SUMMARY AND CONTROL.

| | | | |
|---|---|---|---|
| 1-9 | 11.50 | 8.88 | − 2.62 |
| 10-18 | 1.38 | 1.11 | − 0.27 |
| Mixture of 19-108 inches | 88.02 | 6.97 | −81.05 |
| Total . | 100.90 | 16.96 | −83.94 |

The table of the estimated nitrogen in the produce per acre (p. 128) shows that, from the commencement to 1885 inclusive, the *Trifolium repens* yielded only 261 lb. of nitrogen in crops, but that the *Medicago* gave 917 lb. Again, in 1885, the year of soil-sampling, the *Trifolium* gave only 97 lb., but the *Medicago* gave 270 lb. It is further to be observed that, quite accordantly with the usual character of growth of lucerne in agriculture, with the increasing root-range, and consequently increased command of the stores of the soil and subsoil, the yield of nitrogen increased from 28 lb. in the first and second years, to 337 lb. in the fifth year of growth, declining, however, somewhat afterwards.

Under these circumstances of very large yields of nitrogen in the crops, there is at every one of the twelve depths less,

and at most very much less, nitrogen as nitric acid remaining in the soil than where so much less had been removed in the *Trifolium repens* crops. The difference is distinct even in the upper layers, but it is very striking in the lower depths. Thus there is, on the average, not one-twelfth as much nitric-nitrogen in the lower ten depths of the soil of the deep-rooting and high nitrogen-yielding *Medicago sativa,* as in those of the shallow-rooting and comparatively low nitrogen-yielding *Trifolium repens.* Indeed, the nitric acid is nearly exhausted in the deep-rooting *Medicago sativa* plot; there remaining, to the total depth of 9 feet, only about 17 lb. of nitric-nitrogen against more than 100 lb. to the same depth in the *Trifolium repens* soil. The total deficiency of nitric-nitrogen in the *Medicago* as compared with the *Trifolium repens* soil, is seen to be 85.69 lb. according to one set of determinations, and 83.94 lb. according to the other.

As already said, we cannot know what was the stock of nitric-nitrogen in the soil at the commencement of the growth of the season, or the amount formed during the growing period. But, with so much more *Medicago* growth for several previous years, it seems reasonable to assume that there would be much more nitrogenous crop-residue for nitrification than in the case of the *Trifolium repens* plot.

*Increasing amounts of nitrogen to be accounted for.*

But, even supposing for the sake of illustration, that each year's growth would leave crop-residue yielding an amount of nitrogen as nitric acid for the next crop, or succeeding crops, approximately equal to the amount which had been removed in the crop, the increasing amounts of nitrogen yielded in the crops from year to year could not be so accounted for, and there would remain the amount of nitrogen in the crop-residue itself still to be provided in addition. In fact, assuming the proportion of nitrogen in the crop-residue to that in the removed crop to be as supposed in the above illustration, nearly 700 lb. of nitrogen would have been required for the *Medicago* crop and crop-residue of 1884. Or, if we assume the nitrogen in the residue to be only half that in the crop, about 500 lb. would have been required. Doubtless, however, some of the nitrogenous crop-residue would accumulate from year to year.

*Nitric acid an important source of nitrogen for leguminous crops.*

The results can leave no doubt that the *Trifolium repens,* and the *Medicago sativa,* have each taken up much nitrogen from nitric acid within the soil, and that, in fact, nitric acid is an important source of the nitrogen of the Leguminosæ. Indeed, existing direct experimental evidence relating to nitric acid, carries us quantitatively further than any other line of explanation. But, it is obviously quite inadequate to account for the facts of growth, either in the case of the

*Medicago sativa* after the clover, or in that of the clover after the beans.

*Another source of nitrogen.*

It is obvious that if nitric acid were the source of the whole, there must have been a great deal formed by the nitrification of the nitrogen of the subsoil. A difficulty in the way of the assumption that nitric acid is the exclusive, or even the main source of the nitrogen of the Leguminosæ is, that the direct application of nitrates as manure has comparatively little effect on the growth of such plants. In the case of the direct application of nitrates, however, the nitric acid will percolate chiefly as sodium- or calcium-nitrate, unaccompanied by the other necessary mineral constituents in an available form; whereas in the case of nitric acid being formed by direct action on the subsoil, it is probable that it will be associated with other constituents, liberated, and so rendered available, at the same time.

*Nitrification in raw clays.*

Numerous direct experiments have been made at Rothamsted to determine whether the nitrogen existing in a comparatively insoluble condition in raw clay subsoil was susceptible of nitrification; and the methods and results have been described in various papers. It was established that the nitrogenous matters of raw clay subsoils, which constitute an enormous store of already combined nitrogen, are susceptible of nitrification if the organisms, with the other necessary conditions, including a sufficient supply of oxygen, are present. It was further indicated, not only that the action was more marked under the influence of leguminous than of gramineous growth and crop-residue, but that the organisms become distributed to a considerable depth, even in raw clay subsoils, especially where deep-rooted and free-growing Leguminosæ have developed.

But the data at command do not justify the conclusion that the essential conditions would be adequately available in such cases as those of the very large accumulations of nitrogen by the red clover grown after the beans, and of the increasing and very large accumulations by the *Medicago sativa* for a number of years in succession.

*Nitrogen from the subsoil or the air.*

The alternatives are—either that the plant may take up nitrogen from the subsoil in some other way, as ammonia or as organic nitrogen; or that the free nitrogen of the atmosphere is in some way brought under contribution.

*The power of roots to draw nitrogen from subsoil.*

In reference to the first of these alternatives, the question suggested itself, whether roots, by virtue of their acid sap, may not either directly take up, or at any rate attack and liberate for further change, the otherwise insoluble organic nitrogen of the subsoil?

Accordingly, the root-sap of many plants was examined, and it was found to be more or less acid—that of the deep, strong, fleshy root of the *Medicago sativa* being very strongly so. The degree of acidity of the juice was determined; and attempts were made so to free the extract from nitrogenous bodies as to render it available for determining whether or not it would attack and take up the nitrogen of the raw clay subsoil. These attempts were, however, unsuccessful.

Experiments were next made to determine the action on soils and subsoils of various organic acids, in solutions of a degree of acidity either approximately the same as that of the *Medicago sativa* root-juice, or having a known relation to it. These experiments and their results have been fully detailed elsewhere. It is only necessary to say here that the results did not justify any very definite conclusions as to the probability that the action of roots in the soil, by virtue of their acid sap, is quantitatively an important source of the nitrogen of plants having an extended development of roots, of which the sap is strongly acid.

*Subsoil not the main source of nitrogen accumulated by leguminous crops.*

Indeed, although significant indications have been obtained, both as to the importance of nitric acid as a source of the nitrogen of the Leguminosæ, and as to the action of organic acids in rendering soluble the otherwise insoluble nitrogenous compounds of soils and subsoils, yet on neither of these points is the evidence at present available adequate to account satisfactorily for the facts of growth.

*Soil and manure main sources of nitrogen for most other crops.*

Lastly, in regard to the sources of already combined nitrogen available to our crops, the evidence points to the conclusion that, independently of the small amount of combined nitrogen annually coming from the atmosphere in rain, and the minor aqueous deposits, the source of the nitrogen, at any rate of most of our crops, is the stores already existing within the soil and subsoil, or those provided by manure. It has further been seen that the combined nitrogen is largely taken up as nitric acid, or rather as nitrates. But, it is nevertheless obvious, that we have yet to seek for an explanation of the source of the whole of the nitrogen of the Leguminosæ.

We are brought to inquire, therefore, what is the evidence relating to the question of the *fixation of free nitrogen*, by the plant, by the soil, or otherwise?

## EVIDENCE AS TO FIXATION OF FREE NITROGEN.

It can hardly be said that there remains an unsolved problem in the matter of the sources of the nitrogen of our non-leguminous crops—of wheat, of barley, and of grasses, as representatives of the great Natural Order of the Gramineæ; of turnips, representing the Cruciferæ; of some varieties of beet, representing the Chenopodiaceæ; and of potatoes of the Solaneæ. It must be admitted to be quite otherwise so far as our leguminous crops are concerned.

*Early experiments indicating that plants do not draw nitrogen from the air.*

It is nearly a century since the question whether plants took up, or evolved, free nitrogen became a matter of experiment and of discussion; and it is more than half a century since Boussingault commenced experiments to determine whether plants assimilate free nitrogen.

From his results he concluded that they did not; and those obtained at Rothamsted more than thirty years ago confirmed the conclusions of Boussingault. In fact, we concluded that under the conditions of those experiments, which were those of sterilisation and enclosure, in which, therefore, the action both of electricity and of microbes was excluded, the results were conclusive against the supposition that, under such conditions, the higher chlorophyllous plants can directly fix free nitrogen, either by their leaves or otherwise.

It may, in fact, be concluded that, at any rate in the case of our gramineous, our cruciferous, our chenopodiaceous, and our solaneous crops, free nitrogen is not the source. Nevertheless, we have long admitted that existing evidence was insufficient to explain the source of the whole of the nitrogen of the Leguminosæ; *that there was, in fact, a missing link!*

*A missing link.*

Limiting the discussion here mainly to the question of the sources of the nitrogen of the Leguminosæ, it is generally admitted that all the evidence that has been acquired on lines of inquiry until recently followed, has failed to solve the problem. During the last few years, however, the discussion has assumed a somewhat different aspect.

*The new doctrine.*

The question still is, whether free nitrogen is an important source of the nitrogen of vegetation generally, but especially of the Leguminosæ? But whilst few now assume that the higher chlorophyllous plants directly assimilate free nitrogen, it is nevertheless supposed to be brought under contribution in various ways; but especially by being brought into combination under the influence of micro-organisms, or of other low forms, either within the soil itself, or in symbiotic growth with a higher plant.

*Atwater's experiments.*

Professor Atwater made numerous experiments, both on the germination and on the growth of peas. In eleven out of

thirteen experiments on germination, more or less loss of nitrogen was observed. In all but one out of fifteen experiments on vegetation, there was a gain of nitrogen, which was very variable in amount, and sometimes very large. As a general conclusion, he states that in some of the experiments half or more of the total nitrogen of the plants was acquired from the air.

He considered that germination without loss of nitrogen was the normal process; that loss, whether during germination or growth, was due to decay, and therefore only accessory. He, however, goes into calculations of some of his own results, showing by the side of the actual gains, the greater gains supposing there had been a loss of 15 per cent of nitrogen, and still greater gains if there had been a loss of 45 per cent, as in an experiment by Boussingault under special conditions. Further, he says that whilst actually observed gains are proof of the acquisition of nitrogen, the failure to show gain only proves non-fixation if it be proved that there was no liberation. He suggests that the negative results obtained by Boussingault and at Rothamsted may be accounted for by liberation; though he recognises that the conditions of the experiments excluded the action of either electricity or microbes. It may be remarked that, in the experiments both of Boussingault and at Rothamsted, any cases of decay were carefully observed, and the losses found explained accordingly. It may, in fact, be taken as certain that the conclusions drawn were not vitiated by any such loss.

Atwater concluded that his results did not settle whether the nitrogen gained was acquired as free or combined nitrogen, by the foliage, or by the soil. He considered, however, that in his experiments, the conditions were not favourable for the action either of electricity or of micro-organisms; and he favoured the assumption that the plants themselves were the agents. Lastly, he considered the fact of the acquisition of free nitrogen in some way to be well established; and that thus facts of vegetable production were explained which otherwise would remain unexplained. To this, and other points involved, we shall refer again presently.

*Hellriegel's results.* Of all the recent results bearing upon the subject, those of Hellriegel and Wilfarth with certain leguminous plants seemed to be by far the most definite and significant, pointing to the conclusion that, although the higher chlorophyllous plants may not directly utilise free nitrogen, some of them at any rate may acquire nitrogen brought into combination under the influence of lower organisms; the development of which is apparently in some cases a coincident of the growth of the higher plant whose nutrition they are to serve.

It was in the Agricultural Chemistry Section of the "Naturforscher Versammlung," held in Berlin in 1886, when one of us happened to be presiding, that Professor Hellriegel first announced his new results. Quite consistently, not only with common experience in agriculture, but also with the direct experimental results of ourselves and others, Hellriegel found that plants of the Gramineous, the Chenopodiaceous, the Polygonaceous, and the Cruciferous Orders, depended on combined nitrogen supplied within the soil. On the other hand, he found that leguminous plants did not depend entirely on such supplies. His results were, indeed, not only very definite, but it is seen that they had a special bearing on the admittedly unsolved problem of the source of the whole of the nitrogen of leguminous crops.

In the case of these plants—that of peas, for example—it was observed that, in a series of pots to which no nitrogen was added, most of the plants were apparently limited in their growth by the amount of nitrogen which the seed supplied. Here and there, however, a plant growing under ostensibly the same conditions grew very luxuriantly; and on examination it was found that whilst no nodules were developed on the roots of the plants of limited growth, they were abundant on those of the luxuriantly grown plants. *Root-nodules.*

In view of this result Hellriegel, with his colleague Dr Wilfarth, instituted experiments to determine whether, by the infection of the soil with appropriate organisms, the formation of the root-nodules, and luxuriant growth, could be induced; and whether, by the exclusion of such infection, the result could be prevented. To this end, they added to some of a series of experimental pots 25 or 50 cubic centimetres of the turbid watery extract of a fertile soil, made by shaking a given quantity of it with five times its weight of distilled water, and then allowing the solid matter to subside. In some cases, however, the extract was sterilised. In those in which it was not sterilised, there was almost always luxuriant growth, and abundant formation of root-nodules; but with sterilisation there was no such result. Consistent results were obtained with peas, vetches, and some other Leguminosæ; but the same soil-extract had little or no effect in the case of lupins, serradella, and some other plants of the family which are known to grow more naturally on sandy than on loamy or rich humus soils. Accordingly, they made a similar extract from a diluvial sandy soil, where lupins were growing well, in which, therefore, it might be supposed that the organism peculiar to such a soil would be present; and, on the application of this to a nitrogen-free soil, lupins

grew in it luxuriantly, and nodules were abundantly developed on their roots.

Further particulars of the experiments of Hellriegel and Wilfarth, and also of the results and conclusions of Berthelot, Dehérain, Joulie, Deitzell, Frank, Emil von Wolff, and Atwater, as well as some of the later experiments of Boussingault which have a bearing on the present aspect of the question, will be found in our paper in the *Philosophical Transactions*, vol. 180 (1889), B. A short account is also given of the experiments of Bréal in our paper in the *Proceedings of the Royal Society*, vol. 47, 1890. It may be added that A. Petermann found gain with lupins, but doubted whether it was entirely due to root-nodule action, or whether it was from the combined or the free nitrogen of the air. (Bull. Stat. Agron. Gembloux Belg., March 1890.)

*Hellriegel's results conclusive and all-important.*

Thus, then, not only did Hellriegel and Wilfarth get negative results with plants of other families than the Leguminosæ, as all experience would lead us to expect, but they obtained positive results with the Leguminosæ, in regard to the source of the whole of the nitrogen of which experience showed that there was a "missing link." Such results were obviously of fundamental and of far-reaching importance; and it seemed desirable that the subject should be further investigated with a view to their confirmation or otherwise.

*Recent trials at Rothamsted.*

Accordingly, it was decided to take it up at Rothamsted, and it was hoped to commence experiments in 1887, but it was not possible to do so until 1888. In that year a preliminary series was undertaken, and the investigation has been continued each year since, and is, in fact, not yet completed (1894).

It is proposed to give a brief account of the conditions, and of the results, of these recent experiments made at Rothamsted, which do show a fixation of free nitrogen. But, before doing so, it will be well to call attention to those of the earlier experiments, which did not indicate any fixation; as the well-defined difference in the conditions under which such different results were obtained will bring clearly to view what are the conditions under which fixation does, and what are those under which it does not, take place.

### *Earlier Experiments which did not show Fixation of Free Nitrogen.*

Experiments on the subject were commenced at Rothamsted in 1857; they were continued for several years, and the late Dr Pugh took a prominent part in the inquiry.

The soils used were ignited, washed, and re-ignited pumice

or soil. The specially-made pots were ignited before use, and cooled over sulphuric acid under cover. Each pot with its plants was enclosed under a glass-shade, which rested in the groove of a specially-made, hard-baked, glazed stoneware lute-vessel, mercury being the luting material. Under the shade, through the mercury, passed one tube for the admission of air, another for its exit, and another for the supply of water or solutions to the soil; and there was an outlet at the bottom of the lute-vessel for the escape of the condensed water into a bottle affixed for that purpose, from which it could be removed and returned to the soil at pleasure.

*Plan of the early Rothamsted trials.*

A stream of water being allowed to flow from a tank into a large stoneware Woulff's bottle of more than 20 gallons capacity, the air passed from it by a tube through two small glass Woulff's bottles containing sulphuric acid, and then through a long tube filled with fragments of pumice saturated with sulphuric acid, and lastly through a Woulff's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, the air entered the glass-shade, from which it passed by the exit tube through an eight-bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air was prevented. Carbonic acid was supplied as required, by adding a measured quantity of hydrochloric acid to a bottle containing fragments of marble, the evolved gas passing through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade.

In 1857 twelve sets of such apparatus were employed; in 1858 a larger number, some with larger lute-vessels and shades; in 1859 six, and in 1860 also six. Each year the whole were arranged side by side on stands of brickwork in the open air.

The numerical results obtained in the experiments of 1857 and 1858 are summarised in Table 45 (p. 142).

*No assimilation of free nitrogen.*

The upper part of the table shows the results obtained, in 1857 and 1858, in the experiments in which no combined nitrogen was supplied beyond that contained in the seed sown. The growth was extremely restricted under these conditions; and the figures show that neither with the Gramineæ, the Leguminosæ, nor the Polygonaceæ (buckwheat), was there in any case a gain of three milligrams of nitrogen. In most cases there was much less gain than this, or a slight loss. There was, in fact, nothing in the results to lead to the conclusion that either of these different descriptions of plant had assimilated free nitrogen.

The lower part of the table shows the results obtained in the experiments in which the plants were supplied with

TABLE 45.—SUMMARY OF THE RESULTS OF EXPERIMENTS MADE AT ROTHAMSTED IN 1857 AND 1858, TO DETERMINE WHETHER PLANTS ASSIMILATE FREE NITROGEN.

| | | | Nitrogen. | | |
|---|---|---|---|---|---|
| | | | In seed and manure, if any. | In plants, pot, and soil. | Gain or loss. |
| **WITH NO COMBINED NITROGEN SUPPLIED BEYOND THAT IN THE SEED SOWN.** | | | | | |
| | | | gram. | gram. | gram. |
| Gramineæ | 1857 | Wheat | 0.0080 | 0.0072 | −0.0008 |
| | | Barley | 0.0056 | 0.0072 | +0.0016 |
| | | Barley | 0.0056 | 0.0082 | +0.0026 |
| | 1858 | Wheat | 0.0078 | 0.0081 | +0.0003 |
| | | Barley | 0 0057 | 0.0058 | +0.0001 |
| | | Oats | 0.0063 | 0.0056 | −0.0007 |
| | 1858*a* [1] | Wheat | 0.0078 | 0.0078 | 0.0000 |
| | | Oats | 0.0064 | 0 0063 | −0.0001 |
| Leguminosæ | 1857 | Beans | 0.0796 | 0.0791 | −0.0005 |
| | 1858 | Beans | 0.0750 | 0.0757 | +0.0007 |
| | | Peas | 0.0188 | 0.0167 | −0.0021 |
| Other plants | 1858 | Buckwheat | 0.0200 | 0.0182 | −0.0018 |
| **WITH COMBINED NITROGEN SUPPLIED BEYOND THAT IN THE SEED SOWN.** | | | | | |
| Gramineæ | 1857 | Wheat | 0.0329 | 0.0383 | +0.0054 |
| | | Wheat | 0.0329 | 0.0331 | +0.0002 |
| | | Barley | 0.0326 | 0.0328 | +0.0002 |
| | | Barley | 0.0268 | 0.0337 | +0.0069 |
| | 1858 | Wheat | 0.0548 | 0.0536 | −0.0012 |
| | | Barley | 0.0496 | 0.0464 | −0.0032 |
| | | Oats | 0.0312 | 0.0216 | −0.0096 |
| | 1858*a* [1] | Wheat | 0.0268 | 0.0274 | +0.0006 |
| | | Barley | 0.0257 | 0.0242 | −0.0015 |
| | | Oats | 0.0260 | 0.0198 | −0.0062 |
| Leguminosæ | 1858 | Peas | 0.0227 | 0.0211 | −0.0016 |
| | | Clover | 0.0712 | 0 0665 | −0.0047 |
| | 1858*a* [1] | Beans | 0.0711 | 0.0655 | −0.0056 |
| Other plants | 1858 | Buckwheat | 0.0308 | 0.0292 | −0.0016 |

[1] These experiments were conducted in the apparatus of M. G. Ville.

known quantities of combined nitrogen, in the form of a solution of ammonium-sulphate, applied to the soil. The effect of this direct supply of combined nitrogen was to increase the growth in a very marked degree, especially in the case of the Gramineæ. The figures show that the actual gains or losses of nitrogen ranged a little higher in these experiments in which larger quantities were involved; but they were always represented by units of milligrams only, and the losses were higher than the gains. Further, the gains, such as they were, were all in the experiments with the Gramineæ, whilst there was in each case a loss with the Leguminosæ, and also with the buckwheat. The losses, where beyond the limits that might be expected from experimental error properly so-called, were doubtless due to decay of organic matter, fallen leaves, &c.

It should be stated that the growth was far more healthy with the Gramineæ than with the Leguminosæ, which are, even in the open field, very susceptible to vicissitudes of heat and moisture, and were found to be extremely so under the conditions of enclosure under glass shades. It might be objected, therefore, that the negative results with the Leguminosæ are not so conclusive as those with the Gramineæ. Nevertheless we concluded, and still conclude, from the results of our own experiments, as Boussingault did from his, that neither the Gramineæ nor the Leguminosæ directly assimilate the free nitrogen of the air.

That, under the conditions described, the Leguminosæ as well as the Gramineæ can take up and assimilate already combined nitrogen supplied to them, is clearly illustrated in the experiments made in 1860 with Leguminosæ alone. The series comprised—three experiments with white haricot beans —No. 1 without any other supply of combined nitrogen than that in the seed, No. 2 with a fixed quantity of nitrogen applied as ammonium-sulphate, and No. 3 with a fixed quantity supplied as nitrate; also three experiments with white lupins—No. 1, as with the haricots, without artificial supply of combined nitrogen, No. 2 with supply as ammonium-sulphate, and No. 3 was nitrate. Each of these two descriptions of leguminous plant showed considerably increased growth under the influence both of ammonium-sulphate and of nitrate; indeed the growth was much more satisfactory than in the earlier experiments. Still, owing to the atmospheric conditions within the shades, the plants lost both leaves and flowers, and were, therefore, taken up earlier than they otherwise would have been. The analytical results here again indicated no gain from free nitrogen, either in the experiments without, or in those with, an artificial supply of combined nitrogen—in fact, the losses were greater than the gains.

*Negative results.* *Such, then, were the negative results obtained when plants were grown under conditions of sterilisation and of enclosure. There was, under such conditions, no gain from free nitrogen, in the growth of either Gramineæ, Leguminosæ, or other plants.*

### *Recent Experiments, which do show Fixation of Free Nitrogen.*

*Berthelot's views.* It was about the year 1876, that M. Berthelot called in question the legitimacy of the conclusion that plants do not assimilate the free nitrogen of the air when drawn from the results of experiments in which the plants are so enclosed as to exclude the possibility of electrical action; and later he objected to experiments so conducted with sterilised materials, on the ground that, under such conditions, the presence, development, and action, of micro-organisms are excluded. So far, however, there is nothing in the recent results, either of M. Berthelot himself or of others, which can be held to invalidate the conclusion which had been drawn from the results of Boussingault, and from those obtained at Rothamsted—*that the higher chlorophyllous plants do not directly assimilate free nitrogen.*

Let us now consider what are the results obtained when the conditions of growth involve neither sterilisation nor enclosure.

*Recent Rothamsted trials.* A preliminary series of experiments was commenced in 1888, and a more systematic one in 1889. The plants were grown in specially made pots, and arranged in a glass-house.

In 1888 peas, blue lupins, and yellow lupins, were grown, and there were four pots of each: 1. with washed sand, and the ash of the plant added, but no supply of combined nitrogen beyond a small determined amount in the washed sand, and that in the seed sown; 2. with similarly prepared sand (and ash), but microbe-seeded with the turbid watery extract from a rich garden-soil; 3. duplicate of No. 2; 4. with the rich garden-soil itself. *Root-nodules and gain of nitrogen.* There was, under the influence of soil-extract microbe seeding, considerable formation of nodules on the roots, and considerable gain of nitrogen.

In 1889, as already said, a more extended series was commenced. It included experiments with four annuals—namely, peas, beans, vetches, and yellow lupins; also with four plants of longer life—white clover, red clover, sainfoin, and lucerne. And, as will be seen further on, experiments were commenced in 1890 with the same four annuals, and the same four plants of longer life, on somewhat different lines from those above referred to.

Referring to the experiments in the glass-house, it may be stated that in 1889 and subsequently a purer white sand was

used, which was washed and sterilised by heat. The ash of the plant and a small quantity of calcium-carbonate were added.

There were four pots of each description of plant, excepting in the case of the white clover, of which there were five. For the peas, vetches, beans, white clover, red clover, sainfoin, and lucerne—No. 1 was with the prepared quartz sand without soil-extract; Nos. 2 and 3 were with the quartz sand and garden-soil extract added; and No. 4 was with the garden-soil itself; the fifth pot of white clover receiving calcium-nitrate instead of soil-extract. Of the lupins (both blue and yellow)—No. 1 was with the prepared quartz sand without soil-extract; Nos. 2 and 3 were with lupin-soil extract added; and No. 4 was with the lupin sandy soil itself, to which 0.01 per cent of the plant ash was added.

The analytical details relating to the experiments commenced in 1889, and subsequently, though now completed, have not yet been published, so that numerical results cannot be given here. The following general statement of their bearing will, however, convey a clear idea of their significance and their importance.

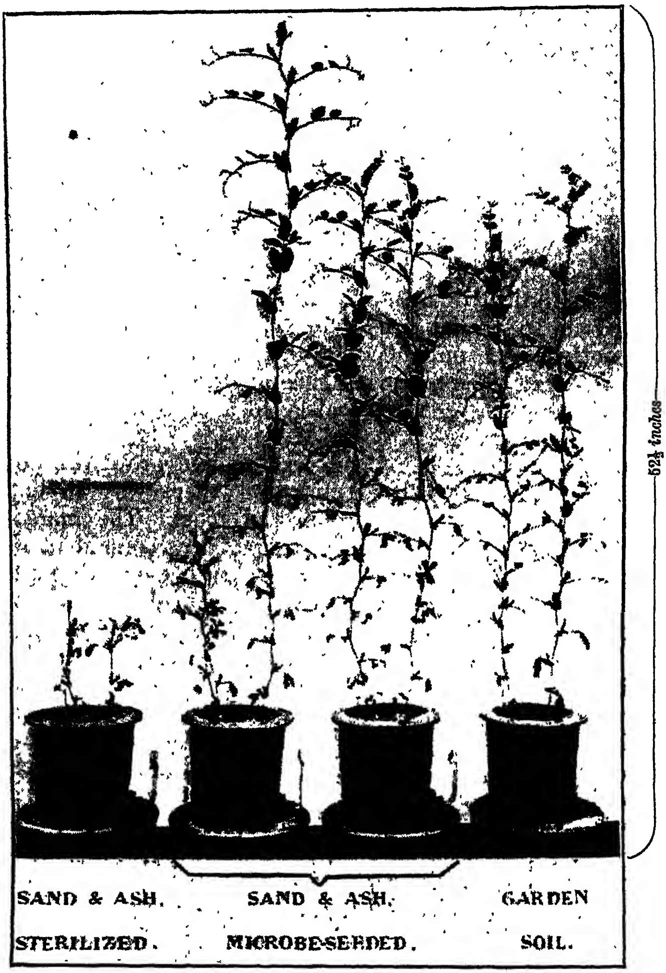
*Fig. 3 explained.*

First as to the *peas*. There was limited growth in pot 1, with sand without soil-extract, and there was an entire absence of nodule-formation on the roots. The increased growth in pots 2 and 3, with soil-extract, was coincident with a very great development of nodules. In pot 4, with garden-soil, itself supplying abundance of combined nitrogen, and doubtless micro-organisms as well, there was also a considerable development of nodules, but distinctly less than in either pot 2 or pot 3 with sand and soil-extract only. Lastly, without soil-extract, and without nodules, there was no gain of nitrogen; but with soil-extract, and with nodule-formation, there was much gain of nitrogen; there being many times as much in the products of growth as in the seed sown. For illustrations of the above-ground growth, see fig. 3.

*Fig. 4 explained.*

With the *vetches*, as with the peas, there was very restricted above-ground growth in pot 1 without soil-extract seeding, and this was associated with very limited root-development, and with the entire absence of nodule-formation. On the other hand, the greatly extended vegetative growth in pots 2 and 3 with soil-extract was associated with an immense development of root and root-fibre, and with the formation of numerous nodules. Again, in the garden-soil, with its liberal supply of combined nitrogen as well as micro-organisms, there was much less development of roots, and less also of nodules, than in the pots with sand and soil-extract only. Further, without microbe-seeding, and with no nodules, there

was no gain of nitrogen; whilst with microbe-seeding, and with numerous nodules, there was considerable gain of nitrogen; there being, with much less nitrogen in the seed, and about the same amount in the products, as in the correspond-

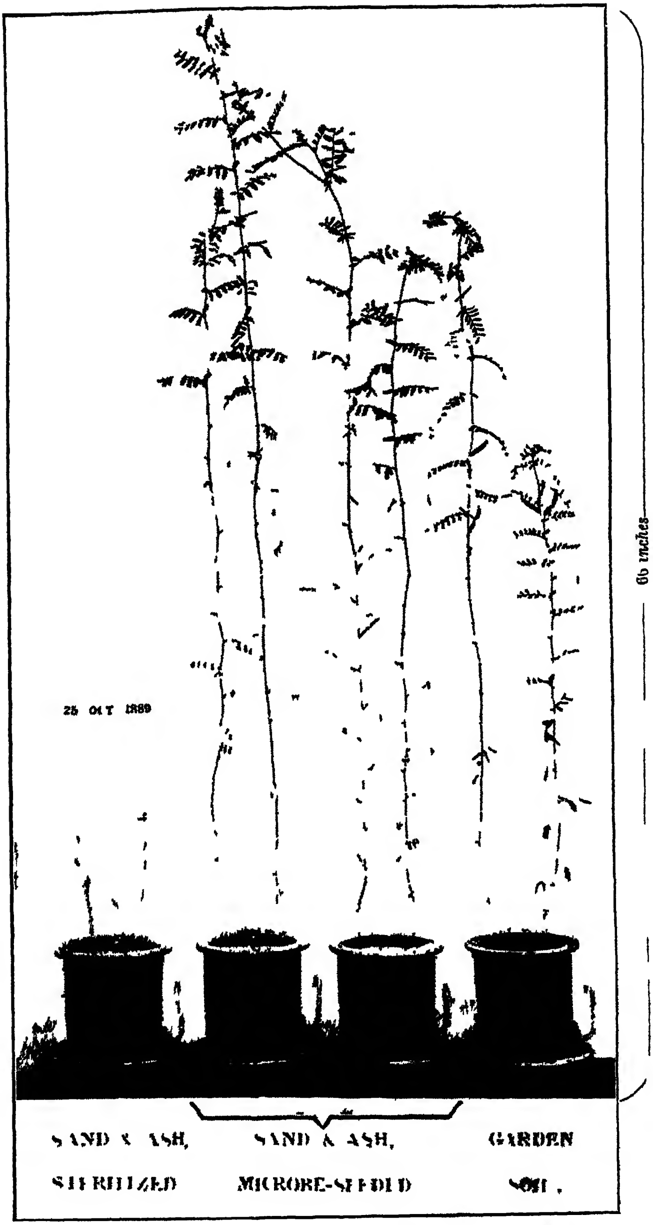



Pot 1. Pot 2. Pot 3. Pot 4.

Fig. 3.—PEAS.

ing experiments with peas, very many times as much nitrogen in the vegetable matter produced as in the seed sown. See fig. 4.

The experiments with *yellow lupins* gave very striking




Pot 1 Pot 2 Pot 3. Pot 4.

Fig. 4—VETCHES.

*Fig. 5 explained.* results. As with the other plants, sterilised sand with ash were used in pots 1, 2, and 3, but pot 4 was filled with sandy soil from a field where lupins were growing. Pot 1 was left without microbe-seeding, but pots 2 and 3 were microbe-seeded by a watery extract of the lupin-soil instead of garden-soil as in the other cases. The results with the yellow lupins were as follows: In the sterilised quartz sand, without microbe-seeding, the growth was extremely limited, both above and under ground. Under the influence of the lupin-soil extract seeding, the above-ground growth was not only very luxuriant, but the plants developed considerable maturing tendency, flowering and seeding freely. The development of the roots generally, and that of swellings or nodules on them, were also very marked. In pot 4, with the lupin-sand itself, which would supply a not immaterial amount of combined nitrogen, although the growth was fairly normal, it was, both above ground and within the soil, much less than in the pots with sand and the soil-extract only; and the development of nodules was also less. It was concluded that the less growth in the lupin-sand itself than in the quartz sand with the lupin-soil extract was largely due to the much less porosity of the lupin-soil, especially when watered.

Again, as with the peas and vetches, so with the lupins, without microbe-seeding there was very limited growth, no formation of nodules, and no gain of nitrogen; but with microbe-seeding there was luxuriant growth, abundant nodule-formation, and, coincidently, great gain of nitrogen. There was, in fact, very many times as much nitrogen in the products of growth as in the seed sown. See fig. 5.

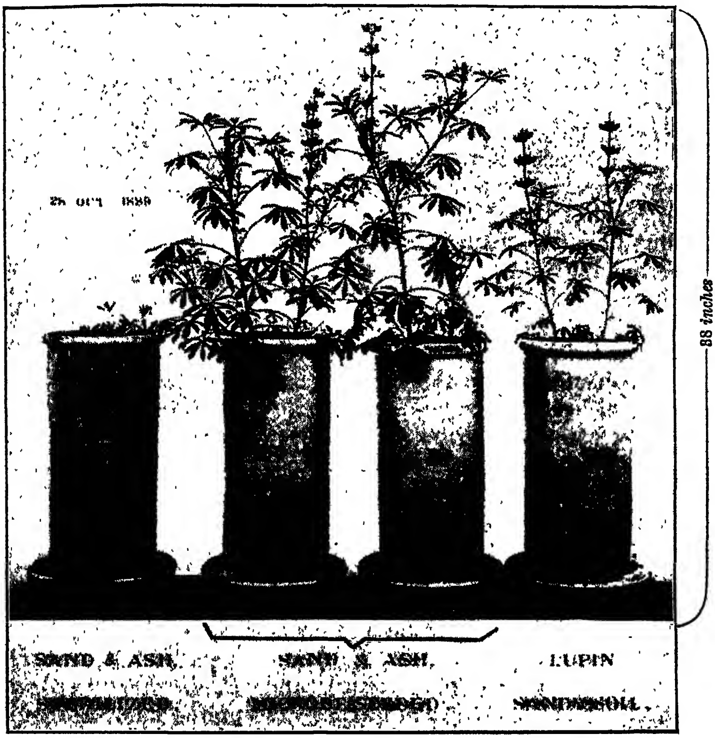
In the experiments with the fourth annual, the beans, the plants suffered much from aphis; the growth was consequently very limited, and the gain of nitrogen but small.

*Results definite and striking.* The results with peas, vetches, and yellow lupins are, however, very definite and very striking. They are abundantly illustrative of the fact that, under the influence of suitable microbe-seeding of the soil, there is nodule-formation on the roots, and, coincidently, increased growth, and gain of nitrogen beyond that supplied in the soil and in the seed as combined nitrogen; presumably due to the fixation, in some way, of free nitrogen.[1]

As already said, experiments were also made with four plants of longer life—white clover, red clover, sainfoin, and lucerne.

[1] M.M. Schloesing *fils* and Laurent have shown, by growing Leguminosæ in closed vessels, and by the analysis of the air before and after growth, that free nitrogen disappeared, in quantity closely corresponding to that gained in growth; thus establishing the fact that the source of the gain was free nitrogen (Compt. Rend. cxi. 750).

The *white clover* was sown in July 1890. Pot 1 was with sand and ash without microbe-seeding; pots 2 and 3 the same with microbe-seeding; pot 4 with garden-soil; and pot 5 with sand and ash, sterilised, but with calcium-nitrate added. Pot 1 gave no cutting, but pots 2, 3, 4, and 5, each gave many cuttings; and the plants were not taken up until December 1892. On the roots of the plants in pot 1 without microbe-seeding there were no nodules, and there was




Pot 1. Pot 2. Pot 3. Pot 4.

Fig. 5.—YELLOW LUPINS.

extremely limited growth; on those in pots 2 and 3 with microbe-seeding there were many nodules, and in each case the produce contained several hundred times as much nitrogen as that in pot 1. There was obviously, therefore, great gain. The plants grown by the nitrate also contained several hundred times as much nitrogen as those in pot 1, but there were no nodules on the roots.

*Great gain in nitrogen.*

The *red clover* was sown in July 1889, yielded many

cuttings, and was not taken up until the winter of 1890-91. Pot 1, without soil-extract seeding, obviously became accidentally microbe-seeded; the growth was considerable, there were nodules on the roots, and there was considerable gain. There was also much nodule-formation, and there was great gain of nitrogen, under the influence of the soil-extract seeding, but less than in the case of the white clover.

The *sainfoin* was sown in June 1890, and the growth was very limited—supposed to be accounted for by imperfect microbe-infection of the roots—and the gain was accordingly but small.

The *lucerne* grew much better than the sainfoin; the roots were much more infected by the microbe-seeding, and there was accordingly considerable gain of nitrogen.

In reference to the failure of growth in the cases where it was apparently due to failure to obtain suitable microbe-infection, it has already been said that Hellriegel at first found great difficulty in ensuring a good result with lupins, serradella, and some other plants, among which was red clover; and the failure to obtain good results at Rothamsted with both blue and yellow lupins in 1888, and with blue lupins in 1889, was doubtless partly due to the same cause.

*Microbe-infection and nodule formation. Nobbe's inquiry.*

As bearing upon this curious and interesting point, it will be well briefly to refer here to the experiments and results of Professor Nobbe on this subject.[1] He undertook an investigation to determine whether leguminous trees, as well as our agricultural leguminous plants, were susceptible to microbe-infection and nodule-formation; and also to ascertain whether there is one nodule-forming bacterium, or whether many bacteria have the property—each description of plant, or perhaps each group, having its special bacterium.

The plants he experimented upon were peas, yellow lupins, and beans; also as trees *Robinia pseudacacia* (locust-tree), *Cytisus laburnum* (laburnum), and *Gleditschia triacantha* (honey locust). To each of these he applied microbe-seeding from various sources; in some cases only soil-extracts, and in others pure cultivations, either from soil-extracts or from the root-nodules of different plants. When soil-extracts only were used, the results were somewhat irregular. But when pure cultivations were employed, the general result was that more effect was produced on any particular description of plant by the bacteria obtained from the same description than by those derived from other descriptions. Nobbe concluded that the results can leave no doubt that the pea and the *Robinia* bacteria have different physiological actions;

[1] *Versuche über die Stickstoff-Assimilation der Leguminosen.* F. Nobbe, E. Schmid, L. Hiltner, E. Hotter, Versuchs-Stationen, xxxix. 327.

which indicate, if not different species or varieties, at any rate different race or nutrition modifications. Beyerinck also concluded that the various papilionaceous bacteria differ more than he had formerly supposed.

Of the three descriptions of leguminous trees upon which Nobbe experimented, the *Robinia* and the *Cytisus*, which are both of the papilionaceous subdivision of the leguminous Order, were susceptible to microbe-infection and nodule-formation on their roots, and showed coincidently gain of nitrogen; but the *Gleditschia*, which is *not* papilionaceous, but of the sub-order Cæsalpinieæ, was quite indifferent to such infection, although both soil-extracts and pure cultivations from various sources were tried. On the other hand, it was found that the application of calcium-nitrate and ammonium-sulphate gave considerably increased growth. Nobbe observes that the roots of *Gleditschia* have a very thick covering, which it would be at any rate difficult for the bacteria to penetrate; but whether the members of this group generally behave differently from the Papilionaceæ in this respect remains for future investigation to determine. It is at any rate of interest to note, that the only leguminous plant outside the papilionaceous sub-order which has yet been experimented upon has not been found susceptible to infection, or to have nodules on its roots.

*Physiological meaning of root-nodules.*

In 1891, F. Nobbe, E. Schmid, L. Hiltner, and E. Hotter, commenced various experiments to ascertain the physiological meaning of the root-nodules of various *non*-leguminous plants (*Eleagnus*, *Hippophaë*, and *Alnus*). *Eleagnus* sprouts were planted in two pots containing sterilised nitrogen-free sand; a week afterwards one pot was infected with an extract of *Eleagnus* soil. The infection had no visible effect during the whole summer, but in the autumn one of the plants began to acquire a somewhat fresher green colour than the others, and in the spring of the following year this plant was unmistakably more vigorous than the others; it was strong, and had side shoots. All the plants (of both pots) were isolated in nitrogen-free sand, when it was seen that only the plant which was benefited by the inoculation had nodules. The non-infected plants were scanty and without side shoots. Only one of the infected plants began to get greener in July 1892; it had three small oblong nodules when taken up.

There was no doubt that *Eleagnus* was enabled by the possession of nodules to utilise free atmospheric nitrogen. The organisms which produced these nodules were obtained in pure cultivations, and were totally different from *Bacterium radicicola*.

Here, then, we have experimental evidence of gain of

*Gain of nitrogen by a non-leguminous plant.*

nitrogen by a non-leguminous plant, but only with the coincidence of nodule-development on the roots.

*Various nodule-forming bacteria.*

The conclusion drawn from the experiments of Nobbe—that there are various nodule-forming bacteria—is at any rate consistent with the descriptions which have been published as to the difference in the external appearance, and the distribution, of the root-nodules in the case of the peas, the vetches, and the lupins, grown at Rothamsted.

Again, the nodules on the roots of lucerne growing in the field were observed at different periods of the season in 1887, and again more recently on plants taken from the field for that purpose; and they are quite different in general external character from those on any other plants that have been examined at Rothamsted.

*Form of root-nodules.*

Among the Leguminosæ growing in the mixed herbage of grass-land, in 1868 nodules were observed on the root-fibres of *Lathyrus pratensis*, especially near the surface of the soil; on the ultimate root-fibres of *Trifolium pratense;* and on the smaller rootlets of *Trifolium repens.* In the case of red clover growing in rotation on arable land, an abundance of nodules has been found, both near the surface and at a considerable depth. They are generally more or less globular or oval. Some found on the main roots were more like "swellings" than attached tubercles, not, however, encasing the root, but only on one side. The greater number are, however, small and chiefly distributed on the root-fibres. Again, on the plot of rich garden-soil on which red clover has now been grown at Rothamsted for forty years in succession, very numerous nodules, chiefly globular and small, have been found on the roots; for the most part within the first few inches of soil, but some to the depth of a foot or more, diminishing, however, very much both in number and in size as the clayey subsoil was reached.

*Fuller evidence required.*

Obviously much more evidence than is at present at command is needed in regard to any difference in character, or relative prevalence, at different periods in the life and growth of the plant, and under different conditions of soil, both so far as mechanical state and porosity, and richness or otherwise in available supplies of combined nitrogen, are concerned, before any clear conception can be attained of the connection between nodule-formation, luxuriance of growth, and gain of nitrogen. The subject in various aspects is being further investigated at Rothamsted, and some of the results so far obtained will be briefly referred to presently.

*How is the Fixation of Nitrogen to be explained?*

Reviewing the whole of the results which have been brought forward, there can be no doubt that the fact of the fixation of free nitrogen in the growth of Leguminosæ under the influence of suitable microbe-infection of the soil, and of the resulting nodule-formation on the roots, may be considered as fully established. How, then, is it to be explained? Unfortunately there is much yet to learn before a satisfactory answer can be given. Obviously we must know more of the nature and mode of life of the organisms which, in symbiosis with the leguminous plant, bring about the fixation of free nitrogen, before the nature of the action can be understood. As to the mode of life of these bodies, we owe much to the investigations of Marshall Ward, Prazmowski, Beyerinck, and others; and some of their results have been discussed in our papers. But the facts which they have established so far are insufficient to afford an adequate explanation of the phenomena involved. Nobbe, also, has recently published results on the subject.

*Assimilation of nitrogen from the air fully established.*

*How is it to be explained?*

It has, indeed, been assumed that the activity of the process depends on the quantity of the nitrogenous compounds at the disposal of the roots—a supposition which implies that the source of nitrogen of the bacteria is the combined nitrogen in the soil. The experimental results which have been described clearly show, however, that the nodules may develop very plentifully in a nitrogen-free soil, and that there may, under such conditions, be great gain of nitrogen if only the soil be suitably infected; nor would there be any such actual gain of nitrogen in nitrogen-free soils as there undoubtedly is, if the source of the nitrogen, either of the parasite or of the host, were essentially the supplies of combined nitrogen within the soil.

*One assumption.*

Further, one assumption is, that the organisms become distributed in the soil, both during the life of the host and afterwards, and that the fixation takes place under their agency within the soil itself rather than in the course of the development of the organisms in symbiosis with the higher plant. Another is, that the fixation takes place in the soil itself under the influence of microbes existing within it, and that the higher plant assimilates the resulting combined nitrogen. As bearing upon these points, it may be observed that in the experiments with peas in 1888 there was practically no gain of nitrogen within the soil itself, which it may be supposed there would have been if the fixation had taken place within it, and the host had acquired its gain from the compounds there produced. Indeed, the evidence at present at command certainly does not point to the conclusion that the gain of

*Other theories.*

nitrogen by Leguminosæ under the influence of microbe-infection of the soil, and nodule-formation, is due to fixation by organisms within the soil itself independently of the symbiosis. It is obvious, too, that so far as free nitrogen may be fixed by microbes within the soil, independently of connection with a higher plant, the resulting nitrogenous compounds should, directly or indirectly, be available to plants generally whether leguminous or non-leguminous.

*Boussingault's results.*

On this point it may be remarked that, from the results of vegetation experiments made by Boussingault in 1858 and 1859, in mixtures of rich soil and sand, he concluded that free nitrogen had been fixed within the soil by the agency of mycodermic vegetation; and that the nitrogenous products which remained within it were largely in the form of organic detritus. Subsequently, however, he considered that there was not satisfactory evidence that free nitrogen is fixed within the soil under the influence of the development of the lower organisms. It is, nevertheless, of interest to observe that those of his results in 1858 and 1859 which showed any material gain of nitrogen, either in the vegetable matter grown or in the soil, were obtained with Leguminosæ; and that, in the case in which there was the greatest gain in the plants themselves, he records that there were numerous tubercles on their roots. In one other case in which, however, only sand was used as soil, and the gain in the plant was but small, he also observed tubercles on the roots. It is at any rate very significant, when viewed in the light of recently acquired knowledge, that in all the cases of gain the plants grown were of the leguminous family, and that in some of them nodules were observed on the roots.

*Berthelot's results.*

Again, Berthelot's experiments showed fixation of free nitrogen by the agency of microbes within the soil, both in the absence of higher vegetation, and also coincidently with the growth of non-leguminous plants. He further considered that such fixation takes place to an extent which would be an important source of nitrogen to our crops. As referred to above, Boussingault's experiments of 1858 and 1859 showed fixation within the soil which he then attributed to the agency of mycodermic vegetation. The fact of such fixation within the soil, under the influence of lower plants, has also been confirmed by the recent results of some other experimenters. Thus, M.M. Schloesing *fils* and Laurent have shown fixation in bare soil, and in soils growing various non-leguminous plants, when certain Lichens and Algæ were developed, but not when their occurrence was prevented. Hellriegel has also found fixation coincidently with the growth of certain Algæ. Nevertheless, it may be observed that neither expe-

*Other results.*

rience in practical agriculture, nor the nitrogen statistics of soils and crops, points to the conclusion that there is gain of nitrogen to any material extent by the fixation of free nitrogen under the agency of microbes within the soil independently of leguminous growth. It was our intention to commence experiments on this subject at Rothamsted in 1891, but we have not yet been able to do so.

*Little gain of nitrogen except with leguminous growth.*

In 1888, however, Berthelot made numerous experiments with Leguminosæ, and in many of them he found very large gains of nitrogen—indeed a much higher range of gain than in his other experiments. That there should be large gain under such conditions is quite consistent with the results which have been recorded of the experiments made at Rothamsted with Leguminosæ, and with those previously obtained by Hellriegel and Wilfarth. Further, these results of Berthelot, like those obtained at Rothamsted and by others with leguminous plants, are consistent with well-established facts of agricultural production, and with the nitrogen statistics of soils and crops, and serve, with them, to aid the solution of long-recognised problems in connection with the growth of leguminous crops.

*Lower organisms preparing food for higher plants.*

But whether or not it may eventually be established that nitrogen is fixed to any material extent by microbes within the soil, independently of leguminous growth, there is evidence that in soils and subsoils containing organic nitrogen, lower organisms may serve the higher plants by taking up or attacking and bringing into a more readily available condition combined nitrogen not otherwise, or only very slowly, available for the higher plants. For example, it is probable that fungi generally derive nitrogen from organic nitrogen; and in the case of those of fairy rings there can be little doubt that they take up from the soil organic nitrogen which is not available to the meadow plants; and that on their decay their nitrogen becomes available to the associated herbage. Then in the case of the fungus-mantle observed by Frank on the roots of certain trees, it may be supposed that the fungus takes up organic nitrogen, and so becomes the medium of the supply of the soil-nitrogen to the plant. More pertinent still is the action of the nitrifying organisms in rendering the organic nitrogen of the soil and subsoil available to the higher plants. It may well be supposed, therefore, that there may be other cases in which lower organisms may serve the higher, bringing into a more available condition the combined nitrogen already existing, but in a comparatively inert state, in soils and subsoils.

*Points established.*

It may, then, be considered as fully established, that various Leguminosæ acquire a considerable amount of nitrogen by

the fixation of free nitrogen under the influence of the symbiotic growth of their root-nodule-microbes and the higher plant; that there is also fixation to some extent, but quantitatively of much less importance, by microbes within the soil; and that there is fixation to some, but to a comparatively immaterial amount, by lower vegetation — such as Fungi, Lichens, and some Algæ. Further, it is established that there is gain from free nitrogen in the case of some *non*-leguminous higher chlorophyllous plants — *Eleagnus*, for example—but as in the case of the Leguminosæ, with the coincidence of root-nodule-microbe development. There still remains the question—Whether there is any fixation by the higher chlorophyllous plants themselves, independently of the associated growth of lower organisms? Frank maintains that there is such fixation by various *non*-leguminous plants.

*A point still unsettled.*

*Petermann's trials.*

In 1892, A. Petermann published the results of experiments with barley in which he found gain of nitrogen, which he attributed to fixation by the plant. He at the same time observed that the surface of the soil was partially covered with Algæ. In 1893, he published the results of further experiments, in which he grew barley both with and without sterilisation. He found no gain with sterilisation, and attributed that shown without it to the lower vegetation with which the surface of the sand was more or less covered. He concluded that barley is not able to fix free nitrogen; but that soils covered with lower vegetation become richer in nitrogen. He considered that the gain in his earlier experiments was not due, as he then supposed, to fixation by the barley itself, but was brought about by the Algæ growing on the surface of the sand. His conclusion was that free nitrogen is not fixed either by the higher plants, or by soil free from lower vegetation. Liebscher, from the results of an elaborate series of experiments with various plants, including white and black mustard, concluded that these cruciferous plants have the power of fixing the free nitrogen of the air, but whether with or without the co-operation of soil-organisms, he considered was not proved. Lotsy, on the other hand, from the results of experiments with the same plants, concludes that there is no such fixation with sterilisation, and that it is uncertain whether it takes place under unsterilised conditions. The question is one of practical as well as scientific interest, as these plants are among those grown for green manuring.

*Barley not able to fix free nitrogen.*

*Lower vegetation and the fixing of free nitrogen.*

Liebscher's experiments certainly appear to have been conducted with very great care under the conditions selected. Nevertheless, it is difficult to accept so important a conclusion from the results of experiments in which from about

11 to 17 kilograms of soil were employed; in which seldom less than 10, and frequently nearer 25 grams of combined nitrogen were involved; in which, with these quantities, the soils and plants were exposed to free air and rain; and in which, under such conditions, there was, with the same description of plant, sometimes loss and sometimes considerable gain of nitrogen indicated. In the case of Papilionaceæ growing in sand, without or with only comparatively small additions of combined nitrogen, but with due microbe-infection, inducing root-nodule-formation, the gains are proportionally so great as to render immaterial the usual sources of error incident to experiments in the open air, and to leave no doubt whatever whether there had been fixation or not. At present, therefore, it must be considered that the fixation of free nitrogen by the higher chlorophyllous plants themselves still requires confirmation. It may be added, that what is known of the nitrogen statistics of the growth in agriculture of other cruciferous plants is adverse to the supposition that they avail themselves of the free nitrogen of the atmosphere.

*Fixation of free nitrogen by the higher chlorophyllous plants requires confirmation.*

But to return to the question of the explanation of the undoubted fixation of free nitrogen in the growth of leguminous crops under the influence of suitable microbe-infection, and of the development of nodules on the roots of the plants.

As in the exact quantitative series of experiments made at Rothamsted in 1888 and since, some of the results of which have been briefly described, the plants were not taken up until they were nearly ripe, it is obvious that the roots and their nodules could not be examined during growth, but only at the conclusion; when, if the gain of nitrogen be connected with their development, it would be supposed that they would be to a great extent exhausted of their nitrogenous contents. Another series was therefore commenced in 1890, and is still in progress, in which the same four annuals—peas, beans, vetches, and yellow lupins, and the same four plants of longer life—white clover, red clover, sainfoin, and lucerne—were grown in specially made pits, so arranged that some of the plants of each description could be taken up, and their roots and nodules studied, at successive periods of growth: the annuals at three periods—namely, first when active vegetation was well established; secondly when it was supposed that the point of maximum accumulation had been approximately reached; and thirdly when nearly ripe: and the plants of longer life at four periods—namely, at the end of the first year, and in the second year when active vegetation was re-established, when the point of maximum accumulation had been reached, and lastly when the seed was nearly

*A recent experiment.*

ripe. Each of the eight descriptions of plant was grown in sand (with the plant ash), watered with the extract from a rich soil; also in a mixture of two parts rich garden-soil and one part of sand. The pits, with their plants, were exposed to the open air, but protected from heavy rain.

*Growth of root-nodules.*

In the sand the infection was comparatively local and limited, but some of the nodules developed to a great size on the roots of the weak plants so grown. In the rich soil the infection was much more general over the whole area of the roots, the nodules were much more numerous, but generally very much smaller. Eventually the nodules were picked off the roots, counted, weighed, and the dry substance and the nitrogen in them determined.

Among the annuals the peas, and among the plants of longer life the sainfoin, showed perhaps the most normal growth; and the results given in Table 46 afford interesting illustrations.

TABLE 46.—EXPERIMENTS AT ROTHAMSTED ON THE FIXATION OF FREE NITROGEN. Plants grown in pits, and taken up at successive periods, 1890-91. 1. In sand (with ash), microbe-seeded; 2. In a mixture of rich soil and sand.

| | | Date of taking up. | Number of plants | Nodules | | | |
|---|---|---|---|---|---|---|---|
| | | | | Approximate number. | Weight, dried at 100° C | Nitrogen. In dry. | Nitrogen. Actual. |
| **PEAS, 1890.** | | | | | | | |
| | | | | | grams | per cent. | grams |
| In sand | 1st period | Aug. 4 | 3 | (253) | 0.229 | 6.630 | 0.0152 |
| | 2nd " | Sept. 24 | 3 | (335) | 0.516 | 3.592 | 0.0185 |
| | 3rd " | Nov. 29 | 3 | (328) | 0.162 | 2.101 | 0.0034 |
| In soil | 1st period | Aug. 5 | 3 | (324) | 0.743 | 5.022 | 0.0373 |
| | 2nd " | Sept. 26 | 3 | (1353) | 1.497 | 3.167 | 0.0474 |
| | 3rd " | Dec. 2 | 3 | (1512) | 1.600 | 2.797 | 0.0447 |
| **SAINFOIN, 1890-91.** | | | | | | | |
| In sand | 1st period | Dec. 10, '90 | 3 | (82) | 0.153 | 7.346 | 0.0112 |
| | 2nd " | May 15, '91 | 3 | (148) | 0.229 | 5.792 | 0.0133 |
| | 3rd " | June 12, '91 | 3 | (360) | 1.043 | 6.151 | 0.0641 |
| | 4th " | Sept. 11, '91 | 3 | (2891) | 4.403 | 4.735 | 0.2085 |
| In soil | 1st period | Dec. 13, '90 | 3 | (226) | 0.040 | 6.259 | 0.0025 |
| | 2nd " | May 15, '91 | 3 | (2018) | 1.492 | 6.286 | 0.0937 |
| | 3rd " | June 12, '91 | 2 | (1125) | 0.649 | 6.363 | 0.0412 |
| | 4th " | Sept. 14, '91 | 3 | (2412) | 3.299 | 7.066 | 0.2331 |

It is seen that, stated very briefly, the general result was that at the third period of growth of the peas in sand, the amount of dry matter of the nodules was very much diminished, the percentage of nitrogen in the dry matter was very much reduced, and the actual quantity of nitrogen remaining in the total nodules was also very much reduced; in fact, the nitrogen of the nodules was almost exhausted. The peas grown in rich soil, however, maintained much more vegetative activity at the conclusion, and showed a very great increase in the number of nodules from the first to the third period; and with this there was also much more dry substance, and even a greater actual quantity of nitrogen in the total nodules at the conclusion. Still, as in the peas grown in sand, the percentage of nitrogen in the dry substance of the nodules was very much reduced at the conclusion. *Nitrogen in root-nodules.*

In the case of the plant of longer life—the sainfoin—there was, both in sand and in soil, very great increase in the number of nodules, and in the actual amount of dry substance and of nitrogen in them, as the growth progressed. The percentage of nitrogen in the dry substance of the nodules also showed, even in the sand, comparatively little reduction, and in the soil even an increase. In fact, separate analyses of nodules of different character, or in different conditions, showed that whilst some were more or less exhausted and contained a less percentage of nitrogen, others contained a high percentage, and were doubtless new and active.

Thus the results pointed to the interesting conclusion that in the case of the annual, when the seed is formed, and the plant more or less exhausted, both the actual amount of nitrogen in the nodules, and its percentage in their dry substance, are greatly reduced; but that with the plant of longer life, although the earlier-formed nodules become exhausted, others are constantly produced, thus providing for future growth. The results of this new series of experiments, taken together with those of the quantitative series, also serve further to show that there is intimate connection between the gain of nitrogen by Leguminosæ, and the development of nodules on their roots. *An interesting conclusion.* *Root-nodules and the gain in nitrogen.*

The alternative explanations of the fixation of free nitrogen in the growth of Leguminosæ seem to be— *Alternative explanations of the fixation of free nitrogen.*

1. That under the conditions of the symbiosis the plant is enabled to fix the free nitrogen of the atmosphere by its leaves.

2. That the nodule-organisms become distributed within the soil, and there fix free nitrogen; the resulting nitrogenous compounds becoming available as a source of nitrogen to the roots of the higher plant.

3. That free nitrogen is fixed in the course of the development of the organisms within the nodules, and that the resulting nitrogenous compounds are absorbed and utilised by the host.

*The most likely explanation.*

Certainly the balance of the evidence at present at command is much in favour of the third mode of explanation. Indeed there seems nothing in the facts to lead to the conclusion that under the influence of the symbiosis the higher plant itself is enabled to fix the free nitrogen of the air by its leaves. Nor does the evidence point to the conclusion that the nodule-organisms become distributed through the soil, and there fix free nitrogen, the compounds of nitrogen so produced being taken up by the higher plant. It seems much more consistent, both with the experimental results and with general views, to suppose that the nodule-organisms fix free nitrogen, and that the nitrogenous compounds produced are absorbed and utilised by the plant.

*Lower organisms serving the higher.*

In other words, there does not seem to be any evidence that the higher chlorophyllous plant itself fixes free nitrogen, or that the fixation takes place within the soil; but it is much more probable that the lower organisms fix the free nitrogen. If this should eventually be established, we have to recognise a new power of living organisms—that of assimilating an elementary substance. But this would only be an extension of the fact that lower organisms are capable of performing assimilation-work which the higher cannot accomplish; whilst it would be a further instance of lower organisms serving the higher.

*Loew's theory.*

Lastly, it may be observed that Loew has suggested that the vegetable cell, with its active protoplasm, if in an alkaline condition, may fix free nitrogen with the formation of ammonium-nitrate. Without passing any judgment on this point, it may be stated that it has frequently been found at Rothamsted that the contents of the nodules have a weak alkaline reaction when in apparently an active condition—that is, while still flesh-red and glistening.

It will be seen that the experimental results which have been brought forward constitute only a small proportion of those obtained at Rothamsted; and it is hoped that when the investigations and the study of them are completed, more definite answers will be forthcoming to some of the admittedly still open questions in connection with this interesting and important subject.

### *Of what Importance to Agriculture is the newly-recognised source of Nitrogen to Leguminous Crops?*

The question yet remains, What is the practical importance of the newly-recognised source of nitrogen to the Leguminosæ, considered in its bearing on the known facts of agricultural production, and especially on the question of the sources of the nitrogen, not only of leguminous crops themselves, but of crops generally? Unfortunately, as in the matter of the explanation of the action by which the nitrogen is fixed, there is much yet to learn before an adequate answer can be given. Still it is desirable to report progress. *The practical importance of the new doctrine.*

It has been stated that the characteristic nodules have been found on the roots of various leguminous plants growing among the mixed herbage of grass-land, and also on those of others growing on arable land, in the ordinary course of agriculture. There can be little doubt that when such plants are growing in soil and subsoil containing an abundance of combined nitrogen, they will obtain some of their nitrogen from nitrates, or other ready-formed compounds of nitrogen. An apparent difficulty in the way of the assumption that much of the greater assimilation of nitrogen by the leguminosæ than by other plants is due to a supply of nitric acid by the nitrification of the combined nitrogen of the subsoil is, that the direct application of nitrates as manure has comparatively little effect on the growth of such plants. In the case of the direct application of nitrates, however, the nitric acid will percolate chiefly as sodium- or calcium-nitrate, unaccompanied by the other necessary mineral constituents in an available condition; whereas in the case of nitric acid being formed as a result of action on the organic nitrogen of the subsoil, it is probable that it will be associated with other constituents liberated, and so rendered available, at the same time.

But, so far as the plants do obtain nitrogen derived from the fixation of free nitrogen, the question arises, Under what conditions will this supply come the more or less into play?

In the later series of experiments made at Rothamsted, those conducted in pits in the open air, to which brief reference has been made, the general, though not the invariable, result was, that there was a much greater number of nodules formed on the roots of the plants growing in rich soil than on those grown in sand. But whilst as a rule the individual, but much fewer, nodules on the roots grown in sand, developed to a much greater size, the much larger number in the soil were very much smaller. *The formation of root-nodules and fixation of free nitrogen.*

As to the smaller number of nodules formed in sand than

in rich soil, the explanation may simply be that, as in the sand the infection was dependent on the additions of rich-soil-extract only, the diffusion of the microbes would be only limited, and the infection of the roots therefore only local or accidental; whilst the much greater size of the individual nodules may be due to the want of power in the more weakly plant growing in nitrogen-free soil to resist the free development of the parasite. On the other hand, in the mixture of rich soil and sand, the microbes would probably be distributed throughout it, and the roots accordingly exposed to infection along their whole range. The much less development of the individual but more numerous nodules in the rich soil may be due to one of two very different causes. It may be that although the more vigorous plants grown in the rich soil could not resist the original infection, they were able to resist the further development of the parasite. Or, it may be that with the vigorous growth, the nodules were more rapidly exhausted of their contents to feed the host. It will be obvious that on the former supposition, some of the nitrogen of the restrictedly developed individual nodules may have been obtained from the nitrogenous matters of the plant itself, derived from soil-nitrogen; in which case the gain from fixation would be less than would otherwise be indicated by the great number of the nodules produced; and in favour of this supposition, which implies that in the early stages of the infection the bacteria derive nitrogenous nutriment from the stores of the higher plant itself, and only later from the fixation of free nitrogen, is the fact of the observed "nitrogen hunger stage" so characteristic of plants for some time after infection when growing in nitrogen-free soil; probably indicating that during that period the limited stores of the plant are being drawn upon. On the second supposition, on the other hand—namely, that the smallness of the nodules was due to their rapid exhaustion by the host—it might be that more of the nitrogen of the nodules would be due to fixation, and that hence a larger proportion of the total nitrogen of the plant would be gain attributable to that source.

Obviously more evidence is needed before a decisive opinion can be formed as to how far fixation of free nitrogen is an essential coincident of nodule-development at all its stages of accumulation, and how far, therefore, the amount of nodule-formation may be taken as a fair measure of the fixation.

It is to be supposed that when nodules develop abundantly on the roots of leguminous plants growing in soil rich in readily available combined nitrogen, the nitrogen assimilated will be partly due to soil-supplies of combined nitrogen, and partly to fixation. That there is gain when red clover, for

example, grows luxuriantly on ordinary arable soil, common experience can leave but little doubt. The evidence of fixation is, however, undoubtedly much the clearer in the case of soils poor in nitrogen. Thus, in the cases of the experiments with peas, vetches, and yellow lupins, growing in nitrogen-free but duly infected sand, there being no other supply of combined nitrogen excepting that in the seed sown, the proportion of the total assimilation due to fixation was undoubtedly very large. It may safely be concluded, indeed, that when luxuriant leguminous crops are obtained on soils characteristically poor in available combined nitrogen, a large proportion of the total nitrogen assimilated will be due to fixation. It is, on the other hand, by no means so clear that when such plants are grown in soil rich in available combined nitrogen, an abundant development of nodules is to be taken as indicating that a correspondingly great proportion of the total nitrogen assimilated is due to fixation.

*Abundant growth of nodules not always indicative of great gain of nitrogen.*

There can, however, be little doubt that in the growth in practical agriculture of leguminous crops, such as clover, vetches, peas, beans, sainfoin, lucerne, &c., at any rate some, and in some cases a considerable proportion, of the large amount of nitrogen which they contain, and of the large amount which they frequently leave as nitrogenous residue in the soil for future crops, is due to the fixation of free nitrogen, brought into combination by the agency of lower organisms. Evidence is, however, obviously still wanting, to enable us to judge decisively under what conditions a greater or less proportion of the total nitrogen of the crop will be derived—on the one hand from nitrogen-compounds within the soil, and on the other from fixation.

*Causes of clover-sickness.*

Incidentally the question suggests itself, How far the failure of red clover, or of other leguminous crops, may be due to the exhaustion of the organisms necessary for nodule-development, and for the coincident fixation of free nitrogen; how far to the exhaustion of combined nitrogen, or of the necessary mineral constituents, in an available condition, within the range of the roots; or, as is sometimes the case, to insect ravages due to the condition of the soil independently of an otherwise failing condition of the plant?

*Sources of nitrogen explained.*

Assuming it then to be established that a greater or less, and sometimes a considerable proportion, of the nitrogen of our leguminous crops will be due to fixation under the conditions supposed, it is obvious that such a fact not only serves to explain the source of the hitherto unaccounted for amount of the nitrogen of those crops themselves, but that it also affords an explanation of the source of the increased amount of nitrogen which other crops acquire when they are grown either

in association, or in alternation, with Leguminosæ. Lastly, the fact that at any rate many leguminous plants, including papilionaceous shrubs and trees, as shown by Nobbe, are susceptible to the symbiosis, and under its influence may gain much nitrogen, serves to explain the source of some at least of the large amount of combined nitrogen accumulated through ages in our soils and subsoils, and also the comparatively slow exhaustion of their stores of it by cropping, drainage, and in other ways.

*Practical aspects of the subject.*

We will, in conclusion, refer to some of the more directly practical aspects of the subject. It may be observed that in Germany, Schultz, of Lupitz, has for some years devoted a considerable area of poor, gravelly, and sandy soil, to the growth of leguminous crops — various clovers, lupins, serradella (*Ornithopus sativus*), &c., by means of kainit and phosphatic manures, and he has found that the land was thereby very much enriched for future cereal and other crops. He finds, however, that it is necessary to vary the description of leguminous crop grown. In other parts of Germany, too, the system is gradually extending of growing lupins, serradella, or other leguminous crops, especially on poor sandy soils, with a view to their enrichment in nitrogen. And, on a large estate in Hungary, visited by one of us in 1891, it was found that the results of the recent investigations indicating the fixation of free nitrogen in the course of the development of leguminous crops were being carefully studied with a view to practical application.

*Enriching poor soils.*

*An Oxfordshire experiment.*

In our own country, Mr Mason, of Eynsham Hall, Oxfordshire, after first making some experiments with various Leguminosæ on small plots, and then a considerable series in specially built tanks or pits, devoted about 200 acres to the practical application of the recently acquired knowledge in regard to nitrogen fixation. Stated in a few words, his idea is to reduce his area under roots, and to grow instead mixed crops of Leguminosæ—beans, various clovers, &c.—liberally manured with basic slag and kainit, and to convert the produce in the first year into silage, and in the second into hay. The land is thus occupied for two years; and the assumption is that in this way highly nitrogenous crops will be obtained with mineral, but without any nitrogenous manure, and that the land will be left in high condition so far as nitrogen is concerned, for the growth of saleable crops, such as grain and potatoes, which require nitrogenous manuring. In other words, his plan is, as he puts it, first to grow nitrogen-accumulating crops for home consumption, and afterwards nitrogen-consuming crops for sale. The experiment has been

*Alternating nitrogen-accumulating crops and*

in progress too short a time to judge how far it will be successful in a series of years, or of rotations. *nitrogen-consuming crops.*

There is, of course, nothing new in the fact that after the growth of a leguminous crop, such as red clover, for example, the soil is left in a higher condition for the subsequent growth of a grain crop; and that, in fact, the growth of such a leguminous crop is to a great extent equivalent to the application of a nitrogenous manure for the cereal. Indeed, history tells us that more than two thousand years ago it was recognised by the Romans that the occasional growth of plants of the leguminous Order had the effect of increasing the growth of the gramineous crops with which they were alternated; and it was stated that the effect was equivalent to that of applying manure. Thus Varro says that "certain things are to be sown, not with the hope of any immediate profit being derived from them, but with a view to the following year, because being ploughed in and then left in the ground, they render the soil afterwards more fruitful;" and the plants used for this purpose were lupins, beans, vetches, and other legumes. *The Romans wise in their day.*

Now, however, that the character of the action is more clearly understood—and it is certain that there is actual gain of nitrogen from sources external to the soil itself—it seems desirable that at any rate tentative trials should be made on different descriptions of soil, with a view of ascertaining whether more advantage cannot be taken of this source of nitrogen than our established practices of rotation at present secure.

To sum up—the experimental results which have been brought forward clearly establish that there is great gain of nitrogen under some conditions. It has also been clearly shown that due infection of the soil, and of the plant, is an essential to success. The evidence at the same time points to the conclusion that the soil may be duly infected for the growth of one description or some descriptions of leguminous plant, but not for some other descriptions. The field experiments on such plants at Rothamsted have further shown that land which is, so to speak, quite exhausted so far as the growth of one leguminous crop is concerned, may still grow very luxuriant crops of another description of the same Order, but of different habits of growth, and especially of different character and range of roots. This result, though undoubtedly more or less due to other causes also, is, nevertheless, in some cases doubtless dependent on the existence, the distribution, and the condition, of the appropriate microbes for the due infection of the different descriptions of plant. In fact, it is pretty certain that success in any system involving a more extended growth of leguminous crops in our *Summary of results*

rotations, will not be attained without having recourse to a considerable variation in the description grown. Other essential conditions of success will generally be the liberal application of potash and phosphatic manures, and sometimes chalking or liming, for the leguminous crop. Then the questions would arise, How long the leguminous crop should occupy the land; to what extent it should be consumed on the land, or the manure from its consumption be returned; or under what conditions the whole, or part, of it should be ploughed in? Lastly, it is probable that more benefit would accrue to the lighter and poorer than to the heavier or richer soils by any such extended growth of leguminous crops.

## *SECTION IV.—EXPERIMENTS ON THE GROWTH OF WHEAT FOR MORE THAN FIFTY YEARS IN SUCCESSION ON THE SAME LAND; BROADBALK FIELD, ROTHAMSTED.*

### Introduction.

*Wheat and barley compared.* It has been already pointed out, that although wheat and barley are closely allied botanically, and they have in some respects very similar requirements, yet that there are distinctions as well as similarities which have to be borne in mind. Thus, whilst in our country and climate barley is generally sown in the spring, wheat is almost always sown in the autumn, and thus has four or five months for root-development, and for gaining possession of range of soil, before barley is sown. In the United States, on the other hand, wheat is to a great extent both a spring and an autumn sown crop; whilst in some other exporting countries it is in some cases a spring and in others an autumn sown crop. At any rate, it is so important a crop in many countries of the world that results relating to its growth, even under widely different conditions, can hardly fail to be of interest to foreign as well as to home growers.

### The Field Experiments on Wheat.

*Plan of the wheat experiments.* The experiments on the continuous growth of wheat at Rothamsted were commenced in the autumn of 1843, the first experimental crop being harvested in 1844; so that the crop of 1894 was the fifty-first grown in succession on the same land—

1. Without manure.
2. With farmyard manure.
3. With a great variety of chemical manures.

Table 47 (p. 168) gives the number of bushels of dressed grain per acre, without manure, and with farmyard manure, in each of the 51 years, 1844 to 1894 inclusive; also on some of the artificially manured plots, mainly selected to illustrate the effects of exhaustion and of manure-residue. In most cases in this table, and in all in the subsequent tables, the results obtained on the artificially manured plots are only given for the last 43 of the 51 years; as, during the first 8 years, various mineral and nitrogenous manures were applied, but not as a rule the same from year to year on the same plot, as they were subsequently.

*Without Manure every year.*

After a five-course rotation since manuring (turnips, barley, peas, wheat, oats), the first experimental wheat crop was harvested in 1844. The highest yield of the whole series of years without manure was 23¼ bushels in 1845, and the lowest 4⅝ bushels in 1879. Other yields have been 21⅛ bushels in 1854, 20 in 1857, only 5⅞ in 1853, and only 8-9 bushels in 1867, 1875, 1876, and 1877.

*Produce of the unmanured plot.*

The upper part of the table (47) shows that the average produce without manure over the first 8 years, 1844-51, was 17⅝ bushels, which was higher than over either of the subsequent 8-yearly periods, due doubtless to a greater amount of comparatively recent accumulations from the previous treatment. In the bottom division of the table is given the average produce for each of the subsequent 8-yearly periods, and for the 40 years, 1852 to 1891 inclusive; also for the whole period of 51 years, 1844-94. It is seen that, without manure, the average annual produce over these 8-yearly periods was—16⅛, 13½, 12¼, 10½, and 12¾ bushels; over the 40 years (1852-91) 13, and over the 51 years (1844-94) 13⅝ bushels.

*Soil exhaustion.*

There can be no doubt that the produce of the unmanured plot has gradually declined; and, independently of the evidence of diminishing produce, analyses of the soil at different periods show that there has been a gradual diminution in the amount of nitrogen in it. But owing to the great fluctuations in the amount of produce from year to year dependent on season, it is by no means easy to estimate the decline due to exhaustion of the soil, as distinguished from variations due to the seasons.

*Former condition of the land.*

In the first place, it is difficult to say what figure should be adopted as the standard produce of the plot by which to compare the yield from year to year. The whole field was manured with farmyard dung in 1839, and then grew tur-

TABLE 47.—WHEAT GROWN FOR 51 YEARS IN SUCCESSION ON THE SAME LAND. Results showing the effects of exhaustion, and of manure-residue. Quantities per acre. Produce: Dressed Grain in bushels.

| | 14 tons farmyard manure every year | Without manure every year. | Mixed mineral manure alone—*blue* | Mixed mineral manure alone—*blue*; ammonium salts alone=86 lb nitrogen—*yellow*, alternately | | Mixed min and amm salts=172 lb N 13 years, 1852-64; Unmanured 19 years 1865-83; Mixed min and sod nit =86 lb N 11 years, 1884-94 | Mineral manure alone—*blue*; ammonium salts alone=86 lb nitrogen—*yellow*; min and amm salts—*green*; unmanured—*white* | |
|---|---|---|---|---|---|---|---|---|
| Plot Nos | 2 | 3 | 5 | 17 | 18 | 16 | 10*a* | 10*b* |
| Harvests | Bushels | Bushels | Bushels | Bushels | Bushels | Bushels | Bushels | Bushels. |
| 1844 | 20½ | 15 | | | | | 15½ | |
| 1845 | 32 | 23½ | | | | | 31⅞ | |
| 1846 | 27½ | 18 | | | | | 27⅜ | 17⅞ |
| 1847 | 29⅞ | 16⅞ | | | | | 25¾ | 25¾ |
| 1848 | 25⅝ | 14¾ | | | | | 19½ | 25⅛ |
| 1849 | 31 | 19½ | | | | | 32⅝ | 32⅜ |
| 1850 | 28½ | 15⅞ | | | | | 27 | 18 |
| 1851 | 20⅝ | 15⅞ | | | | | 28⅞ | 28⅝ |
| 8 years, 1844-51 | 28 | 17¾ | 29 | 30¼ | 28⅞ | 30¾ | 26 | 24⅛ |
| 1852 | 27⅜ | 13⅞ | 16⅞ | 24⅞ | 14¾ | 28½ | 21⅞ | 22⅛ |
| 1853 | 19⅛ | 5⅞ | 10⅛ | 8¾ | 19¼ | 25⅛ | 10 | 15⅛ |
| 1854 | 41⅛ | 21⅛ | 24¼ | 44¼ | 28⅞ | 49⅞ | 34⅜ | 39¼ |
| 1855 | 34⅝ | 17 | 18¼ | 18 | 33¼ | 32⅞ | 20 | 28⅛ |
| 1856 | 36⅛ | 14⅛ | 19⅛ | 31 | 17⅞ | 37⅞ | 24¼ | 27¾ |
| 1857 | 41¼ | 20 | 23¾ | 26¼ | 40⅛ | 49⅝ | 29⅛ | 34½ |
| 1858 | 38¾ | 18 | 18⅞ | 33⅛ | 21¾ | 41⅞ | 22⅞ | 27⅛ |
| 1859 | 36¼ | 18⅜ | 20⅝ | 20⅛ | 32⅝ | 34⅝ | 19 | 25½ |
| 1860 | 32¼ | 12⅞ | 15⅞ | 25¼ | 15¾ | 32⅝ | 15⅛ | 18⅝ |
| 1861 | 34⅞ | 11⅜ | 15⅛ | 18¾ | 32⅞ | 37 | 12⅞ | 16 |
| 1862 | 38⅜ | 16 | 17¾ | 27¾ | 18⅛ | 36¼ | 23⅛ | 24⅞ |
| 1863 | 44 | 17¼ | 19⅝ | 21¼ | 46¼ | 55⅞ | 39⅛ | 43⅝ |
| 1864 | 40 | 16¼ | 16⅞ | 36⅛ | 17⅝ | 51⅛ | 32⅛ | 36½ |
| 1865 | 37⅛ | 13¾ | 14¼ | 17 | 21⅛ | 32¼ | 25¼ | 30⅛ |
| 1866 | 32⅜ | 12⅛ | 13¼ | 26⅛ | 12⅝ | 17¾ | 26¼ | 28½ |
| 1867 | 27½ | 8⅞ | 9¼ | 10¾ | 28⅝ | 14⅛ | 18⅛ | 19⅝ |
| 1868 | 41¼ | 16⅜ | 17⅝ | 37¼ | 18⅝ | 22⅞ | 24½ | 27⅛ |
| 1869 | 38¼ | 14¼ | 15¾ | 16⅛ | 22⅞ | 16⅛ | 20¼ | 19⅛ |
| 1870 | 36⅓ | 15 | 18⅞ | 34⅝ | 19 | 18¼ | 21⅞ | 23¼ |
| 1871 | 30 | 9¾ | 11⅞ | 16 | 28⅜ | 13⅛ | 10⅛ | 10 |
| 1872 | 32⅜ | 10⅞ | 12¾ | 25⅛ | 18 | 13⅛ | 18 | 18¾ |
| 1873 | 26¼ | 11¾ | 12¾ | 11¾ | 20⅝ | 12¼ | 19⅝ | 20⅝ |
| 1874 | 39¼ | 11⅛ | 13 | 33¼ | 14 | 11⅞ | 25¼ | 27¼ |
| 1875 | 28⅞ | 8⅜ | 9½ | 11⅝ | 25⅝ | 10⅛ | 12¾ | 14⅝ |
| 1876 | 23⅞ | 8⅞ | 10⅛ | 26½ | 10⅜ | 11 | 12⅛ | 14¼ |
| 1877 | 24⅛ | 8⅞ | 11⅝ | 10 | 12⅝ | 9⅞ | 17¼ | 18¼ |
| 1878 | 28¼ | 12⅛ | 14½ | 29 | 15¼ | 13⅝ | 27⅜ | 29⅞ |
| 1879 | 16 | 4¾ | 5⅝ | 3⅛ | 20⅛ | 4⅞ | 4 | 4⅝ |
| 1880 | 33¾ | 11¼ | 17⅝ | 32¾ | 15 | 14⅝ | 10⅝ | 18⅜ |
| 1881 | 30¼ | 13⅞ | 12¼ | 13½ | 33 | 13½ | 18¼ | 19⅜ |
| 1882 | 32¼ | 11 | 12½ | 31 | 15⅝ | 10¼ | 23¾ | 20⅞ |
| 1883 | 35¼ | 13⅞ | 15⅜ | 15⅝ | 35¼ | 15⅞ | 17½ | 18⅜ |
| 1884 | 32¼ | 13 | 15⅛ | 33⅞ | 13⅛ | 35 | 25 | 27 |
| 1885 | 40⅞ | 15½ | 15⅛ | 12¾ | 33 | 37⅞ | 24¼ | 24⅜ |
| 1886 | 36¼ | 9 | 11⅛ | 37¾ | 13½ | 44⅝ | 13⅛ | 12½ |
| 1887 | 34⅞ | 14⅞ | 14⅛ | 10⅝ | 30¾ | 39⅝ | 20⅝ | 23 |
| 1888 | 35 | 10 | 12 | 32 | 18⅛ | 33⅞ | 18¼ | 10⅛ |
| 1889 | 40½ | 12¼ | 15⅛ | 10½ | 23⅝ | 29 | 11¼ | 12¾ |
| 1890 | 43 | 14 | 14⅛ | 36⅞ | 20 | 37½ | 18¼ | 20½ |
| 1891 | 45½ | 13¾ | 11¼ | 14⅝ | 31¾ | 42⅞ | 20⅞ | 22⅞ |
| 1892 | 33¾ | 9¾ | 10⅝ | 29 | 12¼ | 31⅝ | 11 | 12 |
| 1893 | 34½ | 9¾ | 14¼ | 13½ | 20⅝ | 19⅛ | 8 | 8¾ |
| 1894 | 45⅞ | 13 | 22⅝ | 37½ | 27¼ | 47 | 28⅞ | 31⅝ |

AVERAGES.

| | 2 | 3 | 5 | 17 | 18 | 16 | 10*a* | 10*b* |
|---|---|---|---|---|---|---|---|---|
| 8 years, 1852-59 | 34⅜ | 16⅛ | 19 | 18⅜ | 32⅝ | 37⅛ | 22¾ | 27⅛ |
| 8 years, 1860-67 | 35¾ | 13⅛ | 15¼ | 16⅛ | 31¼ | 42⅝ [1] | 24 | 27¼ |
| 8 years, 1868-75 | 35⅝ | 12¼ | 14 | 15 | 28¼ | 16⅝ [2] | 19 | 20⅜ |
| 8 years, 1876-83 | 28⅝ | 10⅛ | 12⅝ | 12¼ | 27¾ | 11¾ | 16⅜ | 18⅛ |
| 8 years, 1884-91 | 39¼ | 12¾ | 13⅞ | 18⅛ | 32¼ | 37⅛ | 18⅛ | 19¼ |
| 20 years, 1852-71 | 35⅞ | 14⅛ | 17 | 17¾ | 31⅝ | 32⅜ [3] | 22⅛ | 25⅜ |
| 20 years, 1872-91 | 33½ | 11⅛ | 12⅞ | 12¾ | 29½ | 22 [4] | 17¾ | 19 |
| 40 years, 1852-91 | 34⅞ | 13 | 15 | 15¼ | 30½ | 27¼ | 20⅛ | 22⅛ |
| 51 years, 1844-94 | 33¾ | 13⅝ | .. | .. | .. | | .. | .. |

[1] Average of 5 years, 1860-64 inclusive. [2] Average of 11 years, 1865-75 inclusive.
[3] Average 20 years—first 13 years with mixed mineral and 172 lb. nit per annum, last 7 years unmanured.
[4] Average 20 years—first 12 years unmanured, last 8 years mixed mineral and 86 lb nit. per annum.

nips (fed on the land), barley, peas, wheat, and oats, before the commencement of the experiments in 1843-44. The plot then grew eight crops of wheat without manure, to 1850-51, before the commencement of the period of 40 years to which the averages which have been quoted refer. Although at the conclusion of the five-course rotation since manuring above described, the land would doubtless be, in an agricultural sense, so far exhausted as to require re-manuring, there can be no doubt that there would nevertheless be some accumulation due to comparatively recent manuring and cropping. It would be supposed, however, that the growth of wheat for 8 years in succession without manure would remove most, if not all, accumulation which could be attributed to comparatively recent treatment. Indeed there can be little doubt that the land would suffer more or less exhaustion during these 8 years; but, as serving to counteract the tendency to decline in yield from exhaustion during that period, it happened that, taken together, those eight seasons were of more than average productiveness.

*Fall in produce due to exhaustion.*

The question of the rate of decline due to exhaustion, as distinguished from fluctuation due to season, has been made the subject of elaborate calculation and discussion, which cannot be gone into here; but the general result may be stated as follows:—

Assuming, for reasons which were fully considered, the standard produce of the unmanured plot to have been 16 bushels per acre independently of material exhaustion, there was an average decline from year to year of little more than one-sixth of a bushel over the 40 years 1852-91. It remains to be seen what will be the result in the future; and whether a point has already been, or will in time be reached, at which the produce will remain constant, excepting so far as it is influenced by the fluctuations of the seasons.

*Yield of nitrogen in crop, and loss of nitrogen in drainage.*

It is estimated that over the period of 30 years, 1851-52 to 1880-81, the unmanured plot yielded an average of 18.6 lb. of nitrogen per acre per annum in the crop, and lost a minimum of 10.3 lb. in drainage, in all 28.9 lb.; whilst, on the mixed mineral manure plot (5), it is estimated that the crop removed an average of 20.3 lb. of nitrogen, and that at least 12 lb. were lost by drainage, or in total 32.3 lb. Further, it is estimated that the soils lost to the depth of 27 inches about two-thirds of these amounts; leaving, say, 10 lb., more or less, to be otherwise accounted for. Of this, the rain, &c., would supply 5 lb., or perhaps rather more, and the seed about 2 lb., so that there is but little to be provided from all other sources. Further, as at the commencement the soil was, agriculturally speaking, exhausted,

the nitrogen supplied by it would be largely due to old accumulations.

*Yield without manure exceeds American yield.*

Lastly in regard to the produce of wheat grown so many years in succession without manure, it may be observed that the average yield over 40 years, 1852-91, was 13 bushels per acre per annum, which is more than the average of the whole of the United States, including their rich prairie lands; indeed it is more than the average yield per acre of the wheat lands of the whole world! That the result is not due to richness of soil will be

*Nitrogen in the soil.*

obvious from the fact that the percentage of nitrogen in the dry sifted soil, exclusive of stones, from samples taken in 1893, of every 9 inches of depth, down to 12 times 9, or to a total depth of 9 feet, was, for the respective depths from the first to the twelfth, as follows: 0.1110, 0.0720, 0.0609, 0.0482, 0.0445, 0.0436, 0.0335, 0.0284, 0.0264, 0.0214, 0.0219, and 0.0251.[1] Thus, the percentage of nitrogen in the surface-soil is considerably lower than in the average of wheat-lands in Great Britain; it is considerably less than half as high as in the case of average permanent meadow-land; and it is only about one-third as high as published analyses show in some Illinois prairie soils. The subsoils are also very poor in nitrogen. It is further to be observed that a full mineral manure, annually applied, gave less than ¾ bushel per acre per annum more than the unmanured plot. Hence, it may be concluded that it was not owing to any deficiency of mineral supply, but of nitrogen, that the limita-

*Effect of keeping down weeds.*

tion of the produce was due. On the other hand, that with a soil so poor in nitrogen the yield was nevertheless higher than the average of the United States, or of the world at large, is to be explained by the fact that great care is taken to keep down weeds, which would otherwise appropriate a large share of such fertility as the soil possessed.

### *Farmyard Manure every year.*

In the application of farmyard manure every constituent is supplied in excess. The highest yields of the series of years were—48½ bushels in 1891, 45½ in 1894, 44 in 1863, 43 in 1890, 41¾ in 1868, 41¼ in 1857, 41⅛ in 1854, 40½ in 1889, 40⅛ in 1885, and 40 bushels in 1864. The lowest yields were—16 bushels in 1879, 19⅛ in 1853, 20½ in 1844, 23⅞ in 1876, and 24⅛ in 1877.

The average produce per acre per annum over the first

[1] It should be explained that these samples were not taken in our usual series for analysis, but only from one place, specially to provide illustrative specimens of the soil and subsoil to send to the Chicago Exhibition.

*Produce from farmyard manure.*

8 years was 28 bushels; and the average over each of the five subsequent 8-yearly periods was—$34\frac{3}{8}$, $35\frac{3}{4}$, $35\frac{3}{8}$, $28\frac{5}{8}$, and $39\frac{1}{4}$ bushels. Excluding the first 8 years, the average produce over the 40 years, 1852-91, was $34\frac{7}{8}$ bushels; and the average for the whole period of 51 years, 1844-94, was $33\frac{3}{4}$ bushels per acre per annum.

*Great accumulation of nitrogen.*

On the farmyard manure plot, the first depth of 9 inches shows a great accumulation. It is about twice as rich in nitrogen as any other plot in the field; yet this richness is not proof against bad seasons, nor are the highest amounts of produce in the field obtained on this plot.

*Dung ingredients accumulating in soil and slowly taken up by the crop.*

It has been seen that the unmanured plot has declined in yield and fertility; but there can be no doubt that the farmyard manure plot has, on the other hand, increased in fertility. Analyses of the surface-soil at different periods have shown that it has become about twice as rich in nitrogen as that of the unmanured plot. It has indeed been shown, that a large amount of the constituents of farmyard manure accumulates within the soil, and that they are very slowly taken up by crops. In fact, notwithstanding this great accumulation within the soil, the wheat crops on the dunged plot seldom, if ever, show over-luxuriance; and in unfavourable seasons the produce has been comparatively small, largely owing to the encouragement of weeds, and especially of grass, which in wet seasons it has been impossible effectually to eradicate, and what has been done has not been accomplished without injury to the crop.

*Increased produce due to increased fertility in soil.*

Let us now endeavour to estimate the average annual increase of produce on the farmyard manure plot, due to accumulation, independently of fluctuations due to season, as we did the annual decline in yield on the unmanured plot due to gradual exhaustion. As in the case of the unmanured plot, so in that of the farmyard manure plot, we have founded an estimate of its standard produce, irrespectively of material accumulation, on the yield of the first 8 years; deducting, however, the produce of the first year of all, 1844, as although the yield of the crop of the country at large in that year was high, that of the farmyard manure plot was only 20 bushels. Taking the average of the remaining 7 years of the 8, we get 29.3 bushels, whilst 3 of the 7 yielded more than 30, and 2 others 29 bushels or more. Adopting then 29.3 bushels as the standard yield, irrespectively of material accumulation, the result would be an average annual increase, due to accumulation, of $5\frac{1}{8}$ bushels over the 40 years; whilst the average increase from year to year, if uniform throughout the period, would be a little over $\frac{1}{4}$ bushel over the 40 years.

*Average annual produce.* In conclusion, it is seen that the average produce of the 40 years by farmyard manure was nearly 35 bushels; which is about 7 bushels more than the average of the United Kingdom under ordinary cultivation; and it is not far short of 3 times as much as the average of the United States, or of the whole world!

## *Various Artificial Manures.*

The next question is, Which constituents of farmyard manure are the most effective for wheat in this agriculturally exhausted rather heavy soil, with a raw clay subsoil? The first illustrations on this point will be drawn from Table 48.

*Mineral manure alone.* The average of the 40 years by mineral manure alone shows an increase of only 2 bushels over that of the unmanured plot, though during the preceding 8 years (1844-51) it had received mineral and nitrogenous manures, whilst the unmanured plot had, during the same period, grown eight unmanured wheat crops. *Addition of nitrogen.* The addition to the mineral manure of the first 43 lb. of nitrogen (plot 6) gives an average annual increase of 9⅛ bushels; the second 43 lb. (plot 7) an increase of 9, and the third 43 lb. (plot 8) only 3⅝ bushels increase. This result affords an illustration of the inapplicability of conclusions from manure experiments when the condition of the land is too high already, or when *Nitrate v. ammonia.* an excess of manure is applied. A given quantity of nitrogen in the form of nitrate, yielded more produce than an equal quantity in the form of ammonia. The nitrate, being always applied in the spring, was not subject to winter drainage. It is, however, very soluble, and becomes rapidly distributed and available; but it is at the same time very subject to *Loss of nitrogen by drainage.* drainage after sowing, if heavy rains follow. Prior to 1878, the ammonium-salts were applied in the autumn, and a great loss of nitrogen by winter drainage, chiefly as nitrates, was proved. To the loss of nitrogen by drainage reference will be made further on.

*Increase proportionate to available nitrogen.* Thus, minerals not being deficient, the increase was in proportion to the available nitrogen, when it was not applied in excess.

*Influence of nitrogenous manures on non-nitrogenous constituent of crops.* It will be of interest here to refer to the influence of nitrogenous manures in increasing the production of the non-nitrogenous constituents of our crops, as illustrated in Table 34 (p. 107). It shows the estimated amounts of carbon per acre per annum in various crops grown by mineral manure without nitrogen, and by the same mineral manure

TABLE 48.—WHEAT GROWN FOR MORE THAN 50 YEARS IN SUCCESSION ON THE SAME LAND, COMMENCING 1843-4. Results showing the effects of different Manures for 43 years, 1852-94 inclusive. Quantities per acre. Produce—Dressed Grain in bushels.

| | Superphosphate, and Sulphates Potash, Soda, and Magnesia. | | | | | Sodium nitrate alone =86 lb.[2] nitrogen |
|---|---|---|---|---|---|---|
| | Alone. | And am.-salts =43 lb. nitrogen. | And am.-salts =86 lb. nitrogen. | And am.-salts =129 lb. nitrogen. | And sodium nitrate =86 lb.[1] nitrogen. | |
| Plots. | 5. | 6. | 7. | 8. | 9a. | 9b. |
| Harvests. | Bushels. | Bushels. | Bushels. | Bushels. | Bushels. | Bushels. |
| 1852 | 16⅞ | 20⅞ | 26¾ | 27¼ | 25½ | 24½ |
| 1853 | 10⅝ | 18¼ | 23⅝ | 23½ | 11¼ | 10⅞ |
| 1854 | 24½ | 34⅛ | 43⅞ | 48⅝ | 38¼ | 38⅞ |
| 1855 | 18¼ | 28 | 33 | 31⅞ | 29⅝ | 25⅜ |
| 1856 | 19⅞ | 27¾ | 36⅞ | 39⅞ | 32⅜ | 26 |
| 1857 | 23½ | 35½ | 44⅞ | 48⅜ | 43½ | 36¼ |
| 1858 | 18⅞ | 28¾ | 39⅞ | 41⅞ | 37⅛ | 28⅞ |
| 1859 | 20⅜ | 29⅞ | 34⅝ | 34⅞ | 30 | 24⅝ |
| 1860 | 15⅞ | 22 | 27¾ | 31¼ | 32⅝ | 19⅝ |
| 1861 | 15¼ | 27⅝ | 35 | 35⅞ | 33⅜ | 13¾ |
| 1862 | 17¾ | 28¼ | 35⅞ | 30½ | 48⅞ | 25⅞ |
| 1863 | 19⅝ | 39⅛ | 53⅝ | 55¾ | 55⅜ | 41¼ |
| 1864 | 16⅞ | 31⅜ | 45¼ | 49⅞ | 51¼ | 33¼ |
| 1865 | 14¼ | 25 | 40¾ | 43⅝ | 44⅜ | 29¾ |
| 1866 | 13¼ | 20¾ | 29⅞ | 32¼ | 32¼ | 30¼ |
| 1867 | 9¼ | 15¾ | 22⅜ | 30½ | 29⅝ | 22½ |
| 1868 | 17¾ | 28⅜ | 39⅞ | 40¾ | 47⅞ | 27¼ |
| 1869 | 15¾ | 21⅝ | 28⅛ | 34¾ | 39 | 24¼ |
| 1870 | 18⅞ | 30⅞ | 40⅞ | 45¼ | 45¼ | 20¼ |
| 1871 | 11⅞ | 17 | 22⅞ | 27¼ | 34½ | 17⅛ |
| 1872 | 12¾ | 20¾ | 20¾ | 35⅜ | 40¾ | 23¼ |
| 1873 | 12¾ | 15⅞ | 22 | 27⅞ | 35⅞ | 21⅞ |
| 1874 | 13 | 25¾ | 39⅜ | 40½ | 35¼ | 21¼ |
| 1875 | 9¼ | 16⅜ | 25⅞ | 30 | 30¾ | 16½ |
| 1876 | 10¾ | 13¾ | 23⅛ | 29⅝ | 33⅝ | 13 |
| 1877 | 11⅜ | 14⅝ | 19⅞ | 24¾ | 40⅞ | 27¾ |
| 1878 | 14¾ | 22¾ | 31¼ | 38⅝ | 37¼ | 23¾ |
| 1879 | 5¾ | 10⅞ | 16¼ | 20⅝ | 22 | 4⅝ |
| 1880 | 17¾ | 27 | 34½ | 35½ | 34½ | 10¼ |
| 1881 | 12¾ | 21⅜ | 26⅝ | 30¼ | 35¼ | 22¾ |
| 1882 | 12⅞ | 28⅞ | 35¾ | 37 | 31⅞ | 24⅝ |
| 1883 | 15¾ | 27⅝ | 30⅝ | 41⅞ | 43⅜ | 19⅝ |
| 1884 | 15½ | 20⅞ | 38⅜ | 43¼ | 40⅞ | 27¼ |
| 1885 | 15⅞ | 22 | 31¼ | 30¾ | 31⅞ | 23¼ |
| 1886 | 11¼ | 22¾ | 35⅞ | 42⅜ | 32½ | 15⅞ |
| 1887 | 14⅞ | 28¼ | 20¼ | 34¼ | 30¾ | 23¼ |
| 1888 | 12 | 23¾ | 35⅞ | 35¾ | 28¼ | 16 |
| 1889 | 15⅜ | 23 | 30¼ | 35½ | 26¼ | 12⅝ |
| 1890 | 14¼ | 28⅜ | 36 | 37⅜ | 31¾ | 19¼ |
| 1891 | 11¼ | 26⅜ | 40⅜ | 40 | 35 | 22⅜ |
| 1892 | 10¾ | 22 | 32 | 38⅜ | 25¼ | 10¾ |
| 1893 | 14¼ | 19⅜ | 20¼ | 21¾ | 17⅞ | 10 |
| 1894 | 22⅜ | 38 | 48⅜ | 40 | 43⅜ | 41¼ |
| AVERAGES. | | | | | | |
| 8 years, 1852-59 | 10 | 27⅞ | 35⅜ | 36⅞ | 31⅞ | 26¼ |
| 8 years, 1860-67 | 15½ | 26¼ | 36¼ | 39½ | 40½ | 27⅛ |
| 8 years, 1868-75 | 14 | 22 | 31 | 36 | 39 | 22⅜ |
| 8 years, 1876-83 | 12⅝ | 20⅜ | 28 | 32¼ | 34⅝ | 18¾ |
| 8 years, 1884-91 | 13¾ | 24⅛ | 34⅝ | 38¼ | 32 | 20 |
| 20 years, 1852-71 | 17 | 26¼ | 35¼ | 38¼ | 36⅞ | 26 |
| 20 years, 1872-91 | 12⅞ | 21¾ | 31 | 34¾ | 34 | 19⅜ |
| 40 years, 1852-91 | 15 | 24⅛ | 33⅛ | 36½ | 35⅜ | 22¾ |
| Excess of average crop over Plot 5 in bushels | .. | 9⅛ | 18⅛ | 21½ | 20⅜ | 7¾ |

[1] 9a. Nitrate of soda, equal 74 lb. nitrogen in 1852; equal 43 lb. nitrogen in 1853 and 1854; equal 86 lb. nitrogen in 1854, and each year to 1884 inclusive; and equal 43 lb. nitrogen in 1885, and each year since. No mineral manures applied in 1852, 1853, or 1854.

[2] 9b. Nitrate of soda, equal 74 lb. nitrogen in 1852; equal 86 lb. nitrogen in 1853, and each year to 1884 inclusive; and equal 43 lb. nitrogen in 1885 and each year to 1893 inclusive. In 1894 manured exactly as Plot 9a.

and nitrogenous manure in addition. It also shows—the gain of carbon, that is the increased amount of it assimilated per acre, and the gain of carbohydrates, that is the increased production of them per acre, under the influence of the nitrogenous manures; and lastly, the estimated gain of carbohydrates for 1 of nitrogen supplied in manure. The figures show that, independently of the underground growth, there was an increased assimilation of carbon per acre in wheat—of 602 lb. by the application of 43 lb. nitrogen as ammonium-salts; of 1234 lb. by 86 lb. applied as ammonium-salts; and of 1512 lb. by 86 lb. applied as sodium-nitrate. Or, reckoning the increased production of the non-nitrogenous bodies—the carbohydrates, by the use of nitrogenous manures, it was estimated that there was an increase of 1240 lb. of carbohydrates per acre by the application of 43 lb. nitrogen as ammonium-salts, of 2550 lb. by 86 lb. applied as ammonium-salts, and of 3140 lb. by 86 lb. as sodium-nitrate. To put it in another way—for 1 lb. of nitrogen applied as manure, there was an increased production of carbohydrates in the grain and straw of wheat—of 28.8 lb. when 43 lb. of nitrogen were applied as ammonium-salts, of 29.7 lb. when 86 lb. were applied as ammonium-salts, and of 36.5 lb. when 86 lb. were applied as sodium-nitrate.

*Nitrogen applied in spring and autumn.*

It is seen that in the case of the wheat, there was much more effect from a given amount of nitrogen supplied as nitrate, which was always applied in the spring, than from an equal quantity as ammonium-salts, which were applied in the autumn, when the nitrogen would be subject to winter drainage. Reference to the table will also show that there was more effect from a given amount of ammonium-salts applied to barley than to wheat; the application having been made for the barley in the spring, and for the wheat in the autumn.

*Dependence on available nitrogen.*

It should be observed that there was such greatly increased assimilation of carbon in the wheat and in the barley as the figures show, for more than twenty years, without the addition of any carbon to the soil. It is indeed certain that, in the existing condition of our old arable soils, the increased growth of our staple starch-yielding grains is greatly dependent on an available supply of nitrogen within the soil. It is equally certain that the increased production of sugar in the gramineous sugar-cane in the tropics, is likewise greatly dependent on the supply of nitrogen within the soil.

In connection with the results showing the increased assimilation of carbon, and increased production of carbohydrates, under the influence of nitrogenous manures, it will further be of interest to call attention to the connection

between nitrogen accumulation, chlorophyll-formation, and carbon assimilation.

TABLE 49.—RELATION OF CARBON ASSIMILATION TO NITROGEN ACCUMULATION, AND TO CHLOROPHYLL FORMED.

| | Nitrogen in dry matter.[1] | Relative amounts of chlorophyll | Carbon per acre per annum. | |
|---|---|---|---|---|
| | | | Actual. | Difference |
| | Per cent. | | lb | lb |
| *Hay.* | | | | |
| Gramineæ . . . . | 1.190 | 0.77 | ... | . . |
| Leguminosæ . . . | 2.478 | 2.40 | ... | . . |
| *Wheat.* | | | | |
| Plot 10*a* . . . . | (1.227) | 2.00 | 1398 | −824 |
| Plot 7 . . . . . | (0.566) | 1.00 | 2222 | ... |
| *Barley.* | | | | |
| Plot 1*a* . . . . . | (1.474) | 3.20 | 1403 | −685 |
| Plot 4*a* . . . . . | (0.792) | 1.46 | 2088 | ... |

[1] The figures given in parentheses are on the only partially dried substance.

It should be observed that the amounts of chlorophyll recorded are as stated, *relative*, and not actual; and the figures show the relative amounts for the individual members of each pair of experiments, and not the comparative amounts as between one set of experiments and another. It should be further stated that the chlorophyll determinations were kindly made by Dr W. J. Russell, F.R.S., of London, in specimens collected at Rothamsted, whilst the wheat and barley were still green and actively growing.

*Nitrogen and proportion of chlorophyll.*

It will be seen, in the first place, that the separated leguminous herbage of hay contained a much higher percentage of nitrogen in its dry matter than the separated gramineous herbage; and that, with the much higher percentage of nitrogen in the leguminous herbage, there was also a much higher proportion of chlorophyll.

*Carbon assimilation.*

Next, it is to be observed that the wheat plant on plot 10*a*, manured with ammonium-salts alone, shows a much higher percentage of nitrogen than that of plot 7, with the same amount of ammonium-salts, but with mineral manure in addition. The high proportion of chlorophyll again goes with the high nitrogen percentage; but the last column of the table shows that on plot 10*a*, with ammonium-salts without mineral manure, with the high percentage of nitrogen, and the high proportion of chlorophyll in the green produce, there was eventually a very much less assimilation of carbon.

The result is exactly similar in the case of the barley; plot 1*a* being manured with ammonium-salts alone, and plot 4*a* with the same ammonium-salts and mineral manure in addition.

It is evident that the chlorophyll formation has a close connection with the amount of nitrogen assimilated; but that the carbon assimilation is not in proportion to the chlorophyll formed if there is not a sufficiency of the necessary mineral constituents available. No doubt there had been as much or more of both nitrogen assimilated, and chlorophyll formed, over a given area, where the mineral as well as the nitrogenous manure had been applied; the lower *proportion* of both in the dry matter being due to the greater assimilation of carbon, and consequent greater formation of non-nitrogenous substance.

*Effect of unrecovered nitrogen on succeeding crops.*

The next point to consider is, What is the effect of the unrecovered amount of nitrogen on succeeding crops? This is illustrated by the results in the coloured columns of Table 47 (p. 168). In the table, mineral manure alone is indicated by blue, nitrogenous manure alone by yellow, and a mixture of the two by green. Plot 5 has been manured continuously for 43 years with mineral manure alone; whilst plots 17 and 18 each received, alternately, mineral manure, or a quantity of ammonium-salts containing 86 lb. of nitrogen. Thus we are able, for every year, to compare a plot manured with minerals succeeding a previous application of ammonium-salts, with a plot receiving mineral manure alone every year. It is seen that, in every case, the application of nitrogenous manure gave a greatly increased yield, frequently doubling that of the plot with mineral manure alone. Again, in every case, the yield of the succeeding year, when the mineral manure followed the previous application of ammonium-salts, was reduced approximately to that of the plot continuously treated with minerals alone. A glance down the columns of plots 17 and 18, each coloured alternately blue and yellow, and a comparison of them with the blue column of plot 5, will bring the results strikingly to view. A comparison of the averages of the periods of 8, and of 40 years, of this treatment, clearly shows the essential identity of the results of the continuous and the alternate treatment with mineral manures. The averages for the 40 years show an increase in the yield of the mineral manure after ammonia, over the yield of plot 5 with mineral manure alone every year, of only ¼ of a bushel per acre per annum, in a crop of between 15 and 16 bushels. The non-effect, or the absence, of residual available nitrogen applied in the

*Increase from nitrogenous manure.*

form of ammonium-salts is evident. In other words, nitrogen applied as ammonium-salts in any one year was practically exhausted that year, in the crop, or otherwise; leaving practically none for subsequent action. Lastly, in regard to plots 17 and 18, it is seen that the average produce over 40 years of the ammonium-salts succeeding the mineral manure is 30½ bushels, or exactly twice as much as that of the mineral manure succeeding the ammonium-salt.

*Ammonium-salts exhausted in one year.*

*Yield from heavy manuring.*

Again, plot 16 received annually for 13 years, 1852-64 inclusive, mixed mineral manure and ammonium-salts containing a double quantity (172 lb.) of nitrogen; then for 19 years, 1865-83, it was left unmanured; and then, for the crop of 1884 and each year since, it has received mixed mineral manure and sodium-nitrate containing 86 lb. of nitrogen. During the 13 years of heavy manuring there was a large yield, in two cases exceeding 50 bushels, with an average for the 13 years of 39½ bushels.

*Result of withholding manure.*

The first 3 of the succeeding years during which no manure was applied, the average yield was only 21⅝ bushels, a decrease of nearly one-half, followed in the succeeding two periods of 8 years each by average yields of 16⅝ and 11¾ bushels; against, for the corresponding periods on plot 3, continuously unmanured, 12¼ and 10½ bushels. Or, taking the average of the 19 years of yield without manure on plot 16, we have 14⅝ bushels, against, over the same years, 13⅛ bushels on plot 5 with mineral manure only since 1852, and 11⅜ bushels on plot 3, unmanured since 1839. It is fair to presume, moreover, that some of the greater yields of plot 16 over that of plot 3 from 1865-83, were due to the residue of the mixed mineral and excessive nitrogenous manure, but perhaps mainly, as will be seen further on, to increased crop-residue.

*Manuring resumed.*

Since the re-commencement of the manuring to plot 16 for the crop of 1884, however, the plot has given some heavy yields, notably in 1886 and 1891; and the average for the 8 years, 1884-91, was 37½ bushels, or only 1¾ bushel less than on plot 2, which has received 14 tons of farmyard manure per acre each year for the last 51 years.

*What becomes of surplus nitrogen?*

If, as the above results have demonstrated, there is practically little or no available residue from previous application of ammonium-salts, the question arises, What becomes of the nitrogen of the manure not taken up by the immediate crop? This point is illustrated by the results given in Table 50 (p. 178). The plots there tabulated all received the same amount of nitrogen in manure, but with different mineral manures, and they are given in the order of their average annual increased yield of nitrogen in the crops over plot 5,

with mineral manure alone. The first column shows the estimated average annual increased yield of nitrogen per acre in the crops; the second the estimated annual loss of nitrogen as nitric acid by drainage; the third the estimated annual excess of nitrogen in the surface-soil over that on plot 5 with the mineral manure alone; and the last column shows the relation which the excess in the soil bears to 100 increased yield of nitrogen in the crops.

The plots were manured as follows:—

| Plot | | lb. | |
|---|---|---|---|
| 10. | Ammonium-salts | =86 nitrogen. | |
| 11. | " " | =86 " | and superphosphate. |
| 12. | " " | =86 " | superphosphate and soda. |
| 13. | " " | =86 " | " and potash. |
| 14. | " " | =86 " | " and magnesia. |
| 7. | " " | =86 " | " soda, potash, and magnesia. |
| 9. | Sodium nitrate | =86 " | " soda, potash, and magnesia. |

TABLE 50.—EXPERIMENTS ON WHEAT. Estimated Nitrogen per acre per annum, 30 years, 1851-52 to 1880-81.

| Plots. | In crops over plot 5. | Lost by drainage over plot 5. | In surface-soil 9 inches deep over plot 5. | Excess in surface soil to 100 increase in crop |
|---|---|---|---|---|
| | lb. | lb. | lb. | lb. |
| 10 | 12.4 | 31.2 | 4.8 | 38.7 |
| 11 | 17.7 | 28.5 | 11.6 | 65.5 |
| 12 | 22.2 | 24.5 | 14.6 | 65.8 |
| 13 | 23.4 | 25.6 | 17.8 | 76.1 |
| 14 | 24.1 | 27.5 | 15.5 | 64.3 |
| 7 | 25.9 | 19.0 | 19.3 | 74.5 |
| 9 | 26.5 | 23.7 | 18.5 | 71.2 |

*Nitrogen in the crop.* It is seen that the increased yield of nitrogen in the crops varied exceedingly with the same amount supplied in manure, according to the supply of mineral constituents. Plot 10, with the ammonium-salts alone, gives the smallest increased yield of nitrogen in the crop; and plots 7 and 9, with the most complete mineral manure, each gives more than twice as much; the other plots giving intermediate amounts.

*Loss of nitrogen in drainage.* The order of the estimated loss of nitrogen by drainage is almost the converse of that of the increased yield in the crops. Plot 10, which gives the least increased yield in the crop, shows the greatest loss by drainage; and plots 7 and 9, which yield the greatest increase in the crops, show the least loss by drainage.

The excess in the soils (over plot 5) is obviously much more in the order of the increased yield in the crops. Plot 10, with the least in the increase of crop, and the most in the drainage, shows the least excess in the soil; whilst plots 7 and 9, with the greatest increased yield in the crop, and the least loss by drainage, show the greatest excess in the soil. *Nitrogen in the soil.*

It is clear, therefore, that whilst the excess in the soil has no direct relation to the amount supplied in the manure, it has a very obvious relation to the increased yield in the crop—in other words, to the amount of growth. The last column of the table brings this out more clearly. Excepting in the case of plot 10, with the ammonium-salts alone, there is a general uniformity in the proportion of the excess in the soil over plot 5 to the increased yield in the crop over plot 5; and the variations, such as they are, have an obvious connection with the conditions of growth. Thus, plots 11, 12, and 14, all with a deficient supply of potash, show approximately equal proportions retained in the soil for 100 of increase in the crop. Plots 13, 7, and 9, again, all with liberal supplies of potash, show higher but approximately equal proportions retained in the surface-soil for 100 of increased yield in the crop.

From the various results which have been adduced, it is obvious that the relative excess of nitrogen in the soils of the different plots is little if at all due to the direct retention of the nitrogen of the manure; and that it is almost exclusively dependent on the difference in the amounts of the *crop-residues* (of the stubble and roots, and perhaps of weeds), of which there will be the more the greater the amount of crop grown. *Nitrogen in crop-residue.*

It may be here observed that the detailed estimates, of which the results given in Table 50 are a summary, do not account for the whole of the nitrogen applied to the experimental plots; and it is believed that most, if not the whole, of the unaccounted for amounts are due to loss by drainage beyond that estimated from the pipe drainage. However, in the use of ammonium-salts or nitrate of soda, in smaller quantities per acre than those used in the experiments, and in the course of a rotation of various crops, with varying character and range of roots, as in ordinary agriculture, there will be less loss of nitrogen by drainage than that indicated in these experiments. In the Rothamsted soil and subsoil, with chalk below affording good natural drainage, or in soils generally with good drainage, natural or artificial, it is not probable that there is any material loss by evolution as free nitrogen. Where, however, nitrogen is applied in large *Loss of nitrogen in drainage.* *Evolution of free nitrogen.*

quantities as farmyard or other organic manure, there may be considerable loss by evolution as free nitrogen.

*Effect of nitrogen with different mineral manures.* The next point to consider is the differences in the amount of crop with equal nitrogen, but different mineral supply. This is illustrated by the results in Table 51, which shows the produce by mineral manures alone, by ammonium-salts alone, and by ammonium-salts with different mineral manures.

Over the 40 years, 1852-91 inclusive, each of the eight differently manured plots received, respectively, the same manure each year. Leaving the details for careful examination and study, it will be well to call special attention to the average yields over the first 20, the second 20, and the 40 years.

*Mineral manure.* Plot 5, which received mixed mineral manure alone each year, gave, over the first 20 years, an average annual yield of 17 bushels per acre, over the second 20, 12⅞ bushels, and over the whole period of 40 years, 15 bushels.

*Ammonium salts.* Plot 10*a*, with ammonium-salts alone, each year gave, over the first 20 years an average of 22½ bushels per acre per annum, over the second 20, 17¾ bushels, and over the 40 years 20⅛ bushels. Thus, ammonium-salts alone produced much more than mineral manure alone.

To plot 10*b*, previous to 1852, in the years 1844, 1848, and 1850, mineral manures had been applied; in the other years previous to 1852 (excepting in 1846, when it was unmanured), and each year subsequently, ammonium-salts alone were applied, and the effect of the residue of the mineral manures applied in the early years is apparent on comparison with the yields on 10*a*. *Residue of mineral manures.*

Thus, on plot 10*b*, over the first period of 20 years, there was an average annual yield of 25⅞ bushels per acre, against only 22½ bushels on 10*a*; over the second 20 years 19 bushels, against 17¾ on 10*a*; and over the 40 years an average of 22½ bushels, against only 20⅛ on 10*a*. For further comparison of plots 10*a* and 10*b*, especially in regard to the manuring during the first 8 years, see the last two columns of Table 47 (p. 168), as well as Table 51.

*Potash omitted.* Plot 11, with the ammonium-salts and superphosphate (but no potash), gave, over the first 20 years, an average of 28 bushels per acre, over the second 20, 22¼ bushels, and over the 40 years 25⅛ bushels.

*Sulphate of soda.* On plot 12, in addition to the ammonium-salts and superphosphate, sulphate of soda was applied; but the plot had received potash prior to 1852. The first 20 years after 1852 produced an average of 33⅞ bushels per acre, the second 20 of 27½ bushels, and the whole 40 years of 30⅝ bushels.

TABLE 51.—WHEAT GROWN FOR 51 YEARS IN SUCCESSION ON THE SAME LAND. Results showing the effects of Mineral Manures alone, and when used in addition to Amm.-salts. Quantities per acre. Produce: Dressed Grain in bushels.

| | Mixed mineral manure alone | 400 lb. ammonium-salts=86 lb. nitrogen per acre per annum. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Alone 1852 and since Previously min man 1844 amm salts 1845 51 | Alone 1852 and since Previously min man 1844, '48, and '50, amm salts 1845 '47, 48, 49, and 51 | And superphosphate | And superphosphate and sulphate of soda | And superphosphate and sulphate of potash | And superphosphate and sulphate of magnesia. | And superphosphate and sulphates of potash, soda, and magnesia |
| | Plot 5 | Plot 10a. | Plot 10b | Plot 11 | Plot 12 | Plot 1 | Plot 14 | Plot 7 |
| Harvests 8 years, 1844-51 | Bushels 29 | Bushels 26 | Bushels 24⅜ | Bushels 28½ | Bushels 28⅛ | Bushels 27⅛ | Bushels 27½ | Bushels. 29¼ |
| 1852 | 16⅞ | 21⅞ | 22⅛ | 23¼ | 24⅝ | 24 | 24⅜ | 26¾ |
| 1853 | 10⅛ | 10 | 15⅛ | 18⅛ | 22⅞ | 23 | 22⅛ | 23⅞ |
| 1854 | 24¼ | 34⅜ | 39⅛ | 43⅞ | 45⅝ | 44⅛ | 44¼ | 45⅞ |
| 1855 | 18¼ | 20 | 28⅛ | 21¾ | 31¼ | 30¾ | 31⅜ | 33 |
| 1856 | 19⅛ | 24½ | 27¾ | 31½ | 33⅞ | 31⅝ | 34⅞ | 36⅞ |
| 1857 | 23¾ | 29⅛ | 34½ | 39⅛ | 43¾ | 43⅛ | 43⅝ | 44⅞ |
| 1858 | 18⅞ | 22⅞ | 27¾ | 32 | 37⅝ | 37½ | 38⅛ | 39⅛ |
| 1859 | 20⅝ | 19 | 25½ | 27⅜ | 34¾ | 34½ | 34½ | 34⅝ |
| 1860 | 15⅞ | 15⅛ | 18⅝ | 22⅜ | 27⅜ | 26⅛ | 27¼ | 27¾ |
| 1861 | 15¼ | 12⅞ | 16 | 24⅜ | 32⅞ | 34½ | 33⅜ | 35 |
| 1862 | 17¾ | 23⅛ | 24⅞ | 26⅞ | 33¾ | 32⅜ | 31¼ | 35⅞ |
| 1863 | 19⅝ | 39⅛ | 43⅝ | 45¾ | 54 | 53¼ | 54 | 53⅝ |
| 1864 | 16⅞ | 32⅛ | 36¼ | 36½ | 44⅝ | 43¼ | 41½ | 45¾ |
| 1865 | 14¼ | 25¼ | 30½ | 27⅜ | 34⅝ | 37⅛ | 36⅝ | 40½ |
| 1866 | 18¼ | 26¼ | 28⅛ | 28 | 28¼ | 24¾ | 28 | 29⅞ |
| 1867 | 9¼ | 18⅛ | 19⅜ | 22⅛ | 24½ | 23⅝ | 22¾ | 22⅛ |
| 1868 | 17⅝ | 24¾ | 27¾ | 33½ | 39⅞ | 39¼ | 41¾ | 39⅞ |
| 1869 | 15¾ | 20½ | 19⅛ | 22½ | 27¼ | 27¼ | 27¾ | 28⅝ |
| 1870 | 18⅞ | 21¾ | 28¼ | 25¼ | 35½ | 37 | 35¾ | 40½ |
| 1871 | 11⅞ | 10⅛ | 10 | 11 | 21⅛ | 30⅛ | 24½ | 22¾ |
| 1872 | 12¾ | 18 | 18¾ | 27½ | 29¼ | 29⅞ | 30⅝ | 29¾ |
| 1873 | 12¾ | 19⅝ | 20⅝ | 19½ | 22⅞ | 23 | 24⅛ | 22 |
| 1874 | 13 | 25¼ | 27¼ | 32⅞ | 39½ | 37⅛ | 36⅝ | 39½ |
| 1875 | 9¼ | 12¾ | 14⅝ | 18 | 25¼ | 27⅛ | 26¼ | 25⅞ |
| 1876 | 10½ | 12⅛ | 14½ | 14⅞ | 19⅛ | 25⅛ | 22⅛ | 23⅛ |
| 1877 | 11⅞ | 17¼ | 18¼ | 17⅞ | 17¾ | 18¼ | 18½ | 19⅞ |
| 1878 | 14¾ | 27⅛ | 29¾ | 29⅝ | 29½ | 29½ | 32⅛ | 31¼ |
| 1879 | 5⅛ | 4 | 4⅝ | 11⅛ | 14 | 16 | 16¼ | 16¼ |
| 1880 | 17¼ | 10⅝ | 13½ | 25¾ | 29⅜ | 33 | 31 | 34½ |
| 1881 | 12¼ | 18¼ | 19¾ | 21½ | 23¾ | 25¼ | 27⅜ | 26⅝ |
| 1882 | 12⅛ | 23¾ | 26⅛ | 30⅛ | 34⅝ | 32⅛ | 34¾ | 35¾ |
| 1883 | 15¾ | 17½ | 18⅜ | 26⅜ | 30¾ | 34⅛ | 33⅛ | 36⅛ |
| 1884 | 15⅛ | 25 | 27 | 32⅛ | 35¾ | 33 | 36¼ | 38⅛ |
| 1885 | 15¼ | 24¼ | 24⅞ | 22⅛ | 27⅛ | 27½ | 26⅞ | 31½ |
| 1886 | 11¼ | 13⅛ | 12⅛ | 17¼ | 26⅛ | 37⅛ | 31 | 35½ |
| 1887 | 14½ | 20⅞ | 23 | 22 | 30⅛ | 26⅜ | 28¾ | 20½ |
| 1888 | 12 | 13¼ | 10½ | 11⅛ | 23½ | 33⅝ | 26⅛ | 35⅞ |
| 1889 | 15⅛ | 11⅞ | 12⅞ | 16¼ | 24¼ | 26 | 24¾ | 30¾ |
| 1890 | 14½ | 19½ | 20½ | 25⅝ | 32⅛ | 37¼ | 33⅜ | 36 |
| 1891 | 11½ | 20⅞ | 22⅞ | 24⅛ | 35¾ | 38 | 36½ | 40⅝ |
| 1892 | 10⅜ | 11 | 12 | 15¾ | 24⅛ | 28⅞ | 24⅛ | 32 |
| 1893 | 14¼ | 8 | 8⅞ | 7¾ | 11⅛ | 16⅛ | 12⅞ | 20¼ |
| 1894 | 22⅛ | 28⅞ | 31⅛ | 39 | 47½ | 47¾ | 44¼ | 48⅛ |

AVERAGES.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 years, 1852-59 | 19 | 22¾ | 27⅛ | 29⅝ | 34¼ | 33⅝ | 34¼ | 35⅞ |
| 8 years, 1860-67 | 15¼ | 24 | 27½ | 29⅛ | 35 | 31⅛ | 34⅜ | 36¼ |
| 8 years, 1868-75 | 14 | 19 | 20⅛ | 23⅝ | 30 | 31⅜ | 30⅞ | 31 |
| 8 years, 1876-83 | 12⅝ | 16⅜ | 18⅛ | 22⅛ | 24⅞ | 27 | 27 | 28 |
| 8 years, 1884-91 | 13¾ | 18½ | 19¼ | 21⅜ | 29½ | 32¼ | 30½ | 34¾ |
| 20 years, 1852-71 | 17 | 22⅛ | 25⅞ | 28 | 33⅞ | 33⅞ | 33⅞ | 35¼ |
| 20 years, 1872-91 | 12⅞ | 17¾ | 19 | 22¼ | 27⅛ | 29⅝ | 28⅞ | 31 |
| 40 years, 1852-91 | 15 | 20⅛ | 22½ | 25½ | 30⅜ | 31¾ | 31⅜ | 33⅛ |

*Sulphate of potash.*

To plot 13, besides the ammonium-salts and superphosphate, sulphate of potash was applied each year of the 40, and it had also received potash previously. The average annual produce was, over the first 20 of the 40 years 33⅞ bushels, over the second 20, 29⅝, and over the 40 years 31¾ bushels.

*Sulphate of magnesia.*

On plot 14, besides the ammonium-salts and superphosphate, sulphate of magnesia was applied; and, as on plots 12 and 13, some potash had been applied prior to 1852. The average annual produce was, over the first 20 of the 40 years 33⅞ bushels, over the second 20, 28⅞ bushels, and over the 40 years 31⅜ bushels.

*Sulphate of potash, soda, and magnesia.*

On plot 7, in addition to the ammonium-salts and superphosphate, sulphates of potash, soda, and magnesia were applied; and there was an average annual yield during the first 20 years of 35¼ bushels per acre, during the second 20 of 31 bushels, and during the whole 40 years of 33⅛ bushels.

*Reduction in produce from exhaustion and bad seasons.*

It will be observed that in the case of every one of the plots to which Table 51 refers, and which we have just been considering, the produce is less over the second than over the first 20 years of the 40. Reference to Tables 48 (p. 173) and 47 (p. 168) will show that this was also the case with the produce of every other plot in the field. It was so on plot 7 with the most complete artificial manure; and it was so on plot 2 with farmyard manure every year, and great accumulation of manure-residue from year to year. It is obvious, therefore, that the decline over the latter half of the 40 years is by no means to be attributed exclusively to exhaustion. Reference to the details in the body of the tables, and to the summaries at the bottom of them, will show that there were a good many seasons of considerably less than average produce during the second 20 years of the 40, and that there were some very bad ones, especially in the fourth period of 8 years; so that it is to less favourable seasons that the decline in yield over the latter half of the period must in many cases be largely attributed. Nevertheless, there can be no doubt that exhaustion has had a considerable share in the result in the case of many of the plots.

*Effect of potash.*

Comparing the produce on plots 12, 13, and 14, with that on plot 11 without potash, the effect not only of the direct supply, but of a residue from long previous applications of potash is clearly shown; but the deficiency with residue only, compared with the produce with annual supply of potash, is very evident during the later periods.

Both the amount and the limitation of the effect of the residue, compared with the annual supply of potash, are strikingly illustrated by the results in Table 52. There are there given the amounts, in lb. per acre, of potash, soda, and phos-

phoric acid, removed in the grain, in the straw, and in the total produce (grain and straw together) of plots 11, 12, 13, and 14, above referred to, during each of the four 10-yearly periods of the 40.

TABLE 52.—Potash, Soda, and Phosphoric Acid, per acre per annum, in Grain, in Straw, and in Total Produce, of Wheat. Forty years, 1852-91.

Plot 11. Ammonium-salts=86 lb. nitrogen, and superphosphate.
Plot 12. Ammonium-salts=86 lb. nitrogen, superphosphate, and soda (potash previous to 1852).
Plot 13. Ammonium-salts=86 lb. nitrogen, superphosphate, and potash (potash previous to 1852).
Plot 14. Ammonium-salts=86 lb. nitrogen, superphosphate, and magnesia (potash previous to 1852).

| | In Grain. | | | | In Straw. | | | | In Total Produce. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plot No. . . . | 11. | 12. | 13. | 14. | 11. | 12. | 13. | 14. | 11. | 12. | 13. | 14. |
| **POTASH.** | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb | lb. | lb. |
| 10 years, 1852-61 . | 9.3 | 11.4 | 11.3 | 11.8 | 21.6 | 34.0 | 41.9 | 38.5 | 30.9 | 45.4 | 53.2 | 49.8 |
| 10 years, 1862-71 . | 8.8 | 11.4 | 12.2 | 11.6 | 17.2 | 26.4 | 43.0 | 27.5 | 26.0 | 37.8 | 55.2 | 39.1 |
| 10 years, 1872-81 . | 6.8 | 8.2 | 9.1 | 8.4 | 11.5 | 18.3 | 31.7 | 18.8 | 18.3 | 26.5 | 40.8 | 27.2 |
| 10 years, 1882-91 . | 7.1 | 9.3 | 10.6 | 9.8 | 11.1 | 21.1 | 40.0 | 21.3 | 18.2 | 30.4 | 50.6 | 31.1 |
| 40 years, 1852-91 . | 8.0 | 10.1 | 10.8 | 10.3 | 15.4 | 25.0 | 39.6 | 26.5 | 23.4 | 35.1 | 50.4 | 36.8 |
| **SODA.** | | | | | | | | | | | | |
| 10 years, 1852-61 . | 0.03 | 0.07 | 0.04 | 0.06 | 1.54 | 0.90 | 0.36 | 0.56 | 1.57 | 0.97 | 0.40 | 0.62 |
| 10 years, 1862-71 . | 0.07 | 0.07 | 0.05 | 0.04 | 2.40 | 1.70 | 0.11 | 1.07 | 2.47 | 1.77 | 0.16 | 1.11 |
| 10 years, 1872-81 . | 0.04 | 0.04 | 0.03 | 0.05 | 1.35 | 1.15 | 0.24 | 0.84 | 1.39 | 1.19 | 0.27 | 0.89 |
| 10 years, 1882-91 . | 0.04 | 0.03 | 0.04 | 0.04 | 0.65 | 0.82 | 0.05 | 0.47 | 0.69 | 0.85 | 0.09 | 0.51 |
| 40 years, 1852-91 . | 0.05 | 0.05 | 0.04 | 0.05 | 1.48 | 1.14 | 0.19 | 0.74 | 1.53 | 1.20 | 0.23 | 0.78 |
| **PHOSPHORIC ACID.** | | | | | | | | | | | | |
| 10 years, 1852-61 . | 14.9 | 17.7 | 17.7 | 17.9 | 5.0 | 5.5 | 5.2 | 5.0 | 19.9 | 23.2 | 22.9 | 22.9 |
| 10 years, 1862-71 . | 13.6 | 17.0 | 18.2 | 17.6 | 4.4 | 4.8 | 5.1 | 4.8 | 18.0 | 21.8 | 23.3 | 22.4 |
| 10 years, 1872-81 . | 11.4 | 13.5 | 15.1 | 14.0 | 3.9 | 4.3 | 4.9 | 4.5 | 15.3 | 17.8 | 20.0 | 18.5 |
| 10 years, 1882-91 . | 10.9 | 14.2 | 16.1 | 14.9 | 4.8 | 5.2 | 5.8 | 5.5 | 15.7 | 19.4 | 21.9 | 20.4 |
| 40 years, 1852-91 . | 12.7 | 15.6 | 16.8 | 16.1 | 4.5 | 5.0 | 5.3 | 5.0 | 17.2 | 20.6 | 22.0 | 21.1 |

*Details of experiment.*

As the description above the table shows, each of the four plots, 11, 12, 13, and 14, received annually during the 40 years, 1852-91 inclusive, ammonium-salts=86 lb. nitrogen per acre, and also superphosphate each year. Plot 11 received no potash during the 40 years, nor any during the 8 preceding years of the experiments. Plot 12 received no potash during the 40 years, but a soda-salt instead; it had, however, received 587 lb. of potash per acre during the 8 preceding years. Plot 13 received a liberal supply of potash in each year of the 40, and it had received 737 lb. during the preceding 8 years. Lastly, plot 14 received no potash during

the 40 years, but a magnesia-salt instead; but it had received 566 lb. of potash during the preceding 8 years. Thus, plot 11 received no potash throughout the 48 years; plot 12 none during the 40 years, but there would be a residue from the applications during the preceding 8 years; plot 13 received potash every year of the 40, and a considerable quantity during the preceding 8 years also; and plot 14 none during the 40 years, but had a residue from previous applications.

Complete analyses of the ash of the grain, and of the straw, representing the produce of each of the four successive 10-yearly periods of the 40, of each of the four plots, have been made, by Mr R. Richter, formerly of the Rothamsted Laboratory, but now of Charlottenburg, Berlin. We have, therefore, in the comparison of the amounts of potash in the crops of plots 12 and 14, with only residues of it from long previous applications, with those on plot 11 without any supply at all, and on plot 13 with both residue and an annual supply of it, the means of judging whether the residues from the applications during the preceding 8 years had been effective.

*Amount of potash in wheat as influenced by manure.*

Referring to the amounts of potash stored up in the total produce (grain and straw together), the table shows that, on plot 11, without any supply, the amounts in the crop per acre per annum were, over the four 10-yearly periods—30.9, 26.0, 18.3, and 18.2 lb.; showing, therefore, a very great decline in the amount of potash in the crop where none had been supplied. On plot 12, with no supply during the 40 years, but with residue from applications during the preceding 8 years, the amounts in the crops per acre per annum, over the successive periods were—45.4, 37.8, 26.5, and 30.4; that is, very much more than without any supply at all. On plot 14, again, without annual, but with residual supply, the amounts in the crops were—49.8, 39.1, 27.2, and 31.1 lb.; or even rather more than on plot 12 with residual supply only. Lastly, the amounts of potash in the crops on plot 13, with both annual and residual supply, were—53.2, 55.2, 40.8, and 50.6 lb.; or very much more than on either of the plots with residual supply only. Or, if we take the average amounts of potash in the crops per acre per annum over the 40 years, they were—on plot 11 without any supply, 23.4 lb.; on plot 12, with only residue from previous applications, 35.1 lb.; on plot 14, also with only residue, 36.8 lb.; but on plot 13, with liberal both previous and annual supply,

*Potash residue in soil.*

50.4 lb. That is to say, there was about 1½ time as much stored up in the total produce over the 40 years where there was accumulation from previous applications, as where none had been supplied, and more than twice as much where there

had been full annual supply. The evidence is clear, therefore, that the residue from potash applied before the commencement of the 40 years had been available to the succeeding crops. Indeed, according to calculations showing the balance of supply and removal, it would seem that the whole of the potash residues from the previous applications to plots 12 and 14 were, at the end of the succeeding 40 years, approximately exhausted. It may be added that the Rothamsted experiments afford somewhat similar evidence in regard to phosphoric acid; and both constituents seem to be retained comparatively near the surface of the soil.

*Phosphoric acid.*

It will be remembered that in the case of some of the experimental barley plots, we were enabled to correlate the results of the analyses of the ashes of the crops, with those of determinations of potash in the soils, made by different solvents by Dr Bernard Dyer (see Table 29, p. 89, and context), and that the inquiry proved to be of very much interest. It may be added that Dr Dyer is submitting samples of the soils from the above four plots, among others, in the experimental wheat-field, to similar investigation, and the results will doubtless prove very instructive.

*Dyer's inquiry.*

Detailed examination of the other columns in the Table (52) relating to the potash, will show that there is much less difference in the amounts of it in the grain of the different plots than in that of the straw. Thus, excluding plot 11, where there was no supply, and the produce suffered considerably even early in the 40 years, it is seen that the average amounts of potash per acre per annum in the grain were, on plots 12 and 14, with only residual supply, 10.1 and 10.3 lb., against only 10.8 lb. on plot 13 with full supply. The average annual amounts in the straw were, however, 25.0 and 26.5 lb., with residual supply, against 39.6 lb. on plot 13 with full annual supply. It would thus seem that whilst the plant is in its vegetative stages, it takes up potash largely in proportion to the available supply of it—and it may be in excess of actual requirement if there be abundant supply; whilst, if there be no actual deficiency, the composition of the final product—the seed, is essentially uniform.

*Potash in grain and straw of wheat.*

Referring to the columns relating to soda, it is seen that considerably smaller amounts were found in the produce of wheat than in that of barley. But, as in the case of the barley, the quantities of soda per acre in the total crop were greater where there was a marked deficiency of potash than where soda was actually supplied; whilst the smallest amounts were where the supply of potash was the greatest. Probably the greater amount of soda taken up by the barley than by the wheat is connected with the less root-range, and

*Soda and potash.*

much shorter period of collection, in the case of the spring-sown crop. In both crops, by far the greater proportion of the soda is found in the straw; but there is more in the grain of barley than in that of wheat, due doubtless to the *paleæ* or chaff being adherent and included with the grain in the case of the barley, but not in that of the wheat.

*Phosphoric acid.* With regard to the phosphoric acid results, as superphosphate was applied equally to all four plots, the difference in the amounts taken up and retained are obviously not due to differences of available supply, but are connected with the differences in the amounts of produce due to the supply or deficiency of other constituents. As in the case of the barley, by far the greater part of the phosphoric acid of the whole plant is accumulated in the grain, but the proportion remaining in the straw is greater in the wheat than in the barley.

*Effect of bad seasons.* Reference to the details in the Table (52) will show that generally, and even where there was full supply, there was less of both potash and phosphoric acid in the crops over the third than over the fourth period of 10 years—a result doubtless due to the third period including a more than average proportion of unfavourable seasons, as already referred to when considering the amounts of produce.

*Table 53 explained.* We have thus traced the effects of exhaustion and of full manuring, of nitrogenous and of non-nitrogenous manures, on one particular soil. It has been seen how very different was the effect of one and the same manuring in different seasons; but the real extent of this variation is more clearly brought out in Table 53, which shows the amounts of produce in the best and in the worst seasons of the 40 years, and the average produce over the whole period, under very opposite conditions as to manuring.

TABLE 53.—WHEAT YEAR AFTER YEAR ON THE SAME LAND. Produce of the best Season, 1863; of the worst Season, 1879; and the Average of 40 years, 1852-91.

| Plot | Description of manures—quantities per acre. | Dressed grain per acre—bushels. | | | |
|---|---|---|---|---|---|
| | | Best season, 1863. | Worst season, 1879 | Difference. | Average 40 years, 1852-91 |
| 3 | Unmanured | 17¼ | 4¾ | 12½ | 13 |
| 2 | Farmyard manure | 44 | 16 | 28 | 34⅝ |
| 5 | Mixed mineral manure alone | 19⅝ | 5⅝ | 14 | 15 |
| 6 | Mix. min. man. and 200 lb. am.-salts=43 lb. N | 39⅞ | 10⅛ | 29¾ | 24⅛ |
| 7 | Do. and 400 lb. am.-salts=86 lb. N | 53⅞ | 16¼ | 37⅝ | 33⅞ |
| 9 | Do. and 550 lb.[1] nitrate soda=86 lb. N. | 55⅝ | 22 | 33⅝ | 35⅞ |
| 8 | Do. and 600 lb. am.-salts=129 lb. N. | 55¾ | 20⅜ | 35⅜ | 36⅛ |

[1] 275 lb. nitrate soda=43 lb. nitrogen, 1885 and since

It will suffice to confine attention to the amount of dressed grain per acre, in bushels. The difference in yield of the various plots in the best and worst of the forty seasons is very striking. The unmanured, the mineral manured, and the heavily nitrogenous manured plots, all suffered severely in the bad season. In most cases the difference between the produce of the best and the worst season approached, and in two (plots 6 and 7) it actually exceeded, the average produce of the plots. From these facts it will be seen how easy it is to form wrong conclusions as to the effects of different manures, if experiments are conducted in one season only, or in only a few seasons, and if the characters of the seasons are not studied.

*Produce of the best and the worst seasons.*

Not only season, but soil and locality also must exercise an influence. The Rothamsted results are, of course, obtained on one description of soil, and in one locality. Reference to the following Table (54) will show the results obtained in experiments conducted at Rothamsted during the same 8 years in two different fields: at Woburn, for 7 years; at Holkham, Norfolk, for 3 years; and at Rodmersham, Kent, for 4 years.

*Effect of soil and locality.*

TABLE 54.—RESULTS OF EXPERIMENTS ON THE GROWTH OF WHEAT BY DIFFERENT MANURES, ON DIFFERENT SOILS, IN DIFFERENT LOCALITIES, AND IN DIFFERENT SEASONS.

| Manures; Quantities per acre | Dressed grain per acre—bushels: Rothamsted. 8 years, 1856-63. Broadbalk Field | Rothamsted. 8 years, 1856-63. Hoos-field | Rothamsted. 40 years, 1852-91. Broadbalk Field. | Woburn Beds, 7 years, 1877-83. | Holkham, Norfolk, 3 years, 1852-54. | Rodmersham, Kent, 4 years, 1856-59. |
|---|---|---|---|---|---|---|
| Unmanured | 16 | 15 | 13 | 15⅞ | 18 | 25⅝ |
| Mixed mineral manure alone | 19 | 16⅞ | 15 | 16⅞ | 19⅞ | 28¼ |
| Ammonium salts alone =86 lb nitrogen | 23¼ | 26⅛ | 21⅜ | 23⅝[1] | 27½ | 31¼ |
| Mixed mineral manure and ammonium-salts =86 lb nitrogen | 38½ | 37⅞ | 33⅝ | 37⅝ | 32⅝ | 33½ |

[1] By ammonium-salts=only 43 lb nitrogen

Thus, in experiments made on very various soils, in different conditions from previous treatment, and in various seasons, the general character of the results obtained with each of the four very different conditions as to manuring was accordant. The only marked exception was in the case of Rodmersham, Kent, where the condition of the land was

admittedly higher than was suitable for experiments with different manures. Accordingly, the produce without manure, with mineral manure alone, and with ammonium-salts alone, was higher than that obtained under the same manurial conditions in either of the other localities; whilst the produce of grain with the highest manuring—that is, with the mineral manure and ammonium-salts together—was comparatively low; the crop having been over-luxuriant, with an excessive proportion of straw.

## Summary and General Conclusions.

*Continuous cropping.* It has been shown that root-crops may be grown for many years in succession on ordinary arable land, provided a proper tilth be maintained, and suitable manures are applied. Full crops of barley also have been grown for more than 40 years in succession on such land. Leguminous crops, on the other hand—beans and clover, for example—entirely failed when it was attempted to grow them for many years in succession on ordinary arable land; though large crops of red clover have been obtained for 40 years in succession on rich garden-soil. Lastly, as shown by the results relating to wheat, it has been successfully grown for more than 50 years in succession, without manure, with farmyard manure, and with various artificial manures, on ordinary, and certainly not rich, arable land. The unmanured and the farmyard manure plots have, respectively, been treated exactly in the same way in each of the 50 years. The artificially manured plots, however, as a rule, did not receive the same manure from year to year during the first 8 years, 1844-51; but, with a few special exceptions, each has been treated uniformly during the 43 years, 1852-94 inclusive. Accordingly, most of the comparisons that have been drawn refer to the period of 40 years, 1852-91.

*Effect of manures on wheat.*

*Farmyard manure.* Referring first to the results obtained on the farmyard manure plot, the average annual produce over the 40 years was $34\frac{7}{8}$ bushels, and over the 51 years of $33\frac{3}{4}$ bushels—in the one case nearly 7 bushels, and in the other $5\frac{1}{2}$ bushels, more than the average of the United Kingdom under ordinary rotation; in both not much short of three times the average produce of the United States, and more than $2\frac{1}{2}$ times the average of the whole of the wheat-lands of the world.

*Without manure.* Without any manure whatever, the average annual produce was 13 bushels over the 40, and $13\frac{5}{8}$ bushels over the 51 years; in both cases more than the average of the United States under ordinary cultivation, including their rich prairie lands, and about the average of the whole world.

The results on the artificially manured plots show—that mineral manures alone gave very little increase of produce; that nitrogenous manures alone gave considerably more than mineral manures alone; but that mixtures of the two gave very much more than either separately. In two cases the average produce by mixed mineral and nitrogenous manure was more than that by the annual application of farmyard manure; and in nine out of the twelve cases in which such mixtures were used, the average yield per acre was from 2 to 8 bushels more than the average yield of the United Kingdom (nearly 28 bushels) under ordinary rotation. *Artificial manures.*

Such were the results obtained for 40 or 50 years in succession on ordinary arable land; and that the soil is not a rich one may be judged by the low percentage of nitrogen found in the surface and subsoil.

As bearing upon the question of the yields of wheat of different soils, and different countries, it will be of interest to contrast the condition of soils of very different history in relation to their percentage of nitrogen, and, where practicable, of carbon also. Table 55 (p. 190) shows the characters in these respects—of arable soil under rotation and in fairly good condition; of that of the experimental wheat-field variously manured; of exhausted arable soils, of newly laid-down permanent grass-land, and of old grass-land, at Rothamsted. It also gives results relating to some other old arable soils; to some United States and Canadian prairie soils; and lastly, to some rich Russian soils. *Nitrogen and carbon in soils.*

Unfortunately, in the early years of the Rothamsted experiments, samples of soil were not taken of a fixed area, and to a fixed depth, so that the results of nitrogen determinations in them are not comparable with those taken at later dates to the uniform depth of 9 inches. It is difficult, therefore, accurately to estimate the percentage of nitrogen in the wheat-field surface-soil at the commencement of the experiments. Some idea may, however, be formed from the results given in the table. Thus, it is seen that in a field which, from 1848 up to the present time, has been under 4-course rotation of—roots (fed on the land), barley, leguminous crop, and wheat, with mineral and nitrogenous manure for the roots commencing each course, the percentages of nitrogen in the dry sifted soil were—in 1867 after the fourth crop since manuring (wheat), 0.1402; in 1874 after the third crop since manuring (clover), 0.1372 per cent; and in 1883, again after the fourth crop (the wheat), 0.1391 per cent. Here, then, under rotation and liberal manuring, and the feeding of the roots on the land, the average percentage of nitrogen in the surface-soil is maintained at nearly

## TABLE 55.—Nitrogen and Carbon in various Soils.

| | Date of soil-sampling. | In dry sifted soil.[1] Nitrogen. | Carbon. | Carbon to 1 nitrogen. | Authority. |
|---|---|---|---|---|---|
| **ROTHAMSTED ARABLE AND GRASS SOILS.** | | | | | |
| | | per cent | per cent. | | |
| 4-course rotation, 1848 and since; fully manured for roots, each course | 1867, after wheat | 0.1402 | .. | .. | Rothamsted. |
| | 1874, after clover | 0.1372 | .. | .. | |
| | 1883, after wheat | 0.1391 | .. | .. | |
| Wheat, 1843-44, and each year since. Farmyard manure, every year | October 1865 | 0.1882 | 1.836 | 9.8 | |
| | " 1881 | 0.1957 | 2.294 | 11.7 | |
| Wheat, 1843-44, and each year since. Mineral and nitrogenous manure | " 1865 | 0.1230 | 1.180 | 9.6 | |
| | " 1881 | 0.1264 | 1.341 | 10.6 | |
| Wheat, 1843-44, and each year since. Mineral manure alone | " 1865 | 0.1119 | 1.039 | 9.3 | |
| | " 1881 | 0.1012 | 1.080 | 10.7 | |
| Wheat, 1843-44, and each year since. Unmanured | " 1865 | 0.1090 | 0.978 | 9.0 | |
| | " 1881 | 0.1045 | 1.017 | 9.7 | |
| Barley, 1852, and each year since; mineral manures alone | March 1868 | 0.1202 | .. | .. | |
| | " 1882 | 0.1124 | 1.154 | 10.3 | |
| Roots, 1843-52; barley, 1853-55; roots, 1856-69; mineral manures alone | April 1870 | 0.0934 | .. | .. | |
| Arable laid down to grass (10 acres), spring, 1879 | February 1882 | 0.1235 | .. | .. | |
| Arable laid down to grass (Barnfield), spring, 1874 | " " | 0.1509 | .. | .. | |
| Arable laid down to grass (Appletree field), spring, 1868 | November 1881 | 0.1740 | .. | .. | |
| Arable laid down to grass (Dr Gilbert's meadow), spring, 1858 | January 1879 | 0.2057 | 2.412 | 11.7 | |
| Arable laid down to grass (Highfield), spring (?), 1838 | September 1878 | 0.1943 | 2.403 | 12.4 | |
| Very old grass-land (The Park) | Feb. and March 1876 | 0.2466 | 3.377 | 13.7 | |
| **VARIOUS ARABLE SOILS IN GREAT BRITAIN.** | | | | | |
| Mr Prout's Farm: Broadfield—surface | .. | 0.170 | .. | .. | Voelcker. |
| Mr Prout's Farm: Blackacre—surface | .. | 0.107 | .. | .. | |
| Mr Prout's Farm: Whitemoor—surface | .. | 0.171 | .. | .. | |
| Wheat soils: Mid-Lothian | .. | 0.22 | .. | .. | Anderson. |
| Wheat soils: East Lothian | .. | 0.13 | .. | .. | |
| Wheat soils: Perthshire | .. | 0.21 | .. | .. | |
| Wheat soils: Berwickshire | .. | 0.14 | .. | .. | |
| Red Sandstone soil: England | .. | 0.18 | .. | .. | Voelcker. |
| **UNITED STATES AND CANADIAN PRAIRIE SOILS.** | | | | | |
| United States—Illinois: No. 1 | .. | 0.30 | .. | .. | Voelcker. |
| United States—Illinois: No. 2 | .. | 0.26 | .. | .. | |
| United States—Illinois: No. 3 | .. | 0.33 | .. | .. | |
| United States—Illinois: No. 4 | .. | 0.34 | .. | .. | |
| Canada: Manitoba; Portage la Prairie—surface | .. | 0.247 | .. | .. | Rothamsted. |
| Canada: N.W. Territory; Saskatchewan district—surface | .. | 0.303 | .. | .. | |
| Canada: N.W. Territory; 40 miles from Fort Ellice—surface | .. | 0.250 | .. | .. | |
| Canada: Manitoba: Niverville—first 12 inches | .. | 0.261 | 3.42 | 13.1 | Rothamsted. |
| Canada: Manitoba: Brandon " | .. | 0.187 | 2.66 | 14.2 | |
| Canada: Manitoba: Selkirk " | .. | 0.618 | 7.58 | 12.3 | |
| Canada: Manitoba: Winnipeg " | .. | 0.425 | 5.21 | 12.2 | |
| **RUSSIAN SOILS.** | | | | | |
| No. 1—12 inches | .. | 0.607 | .. | .. | C. Schmidt. |
| No. 2— 8 " | .. | 0.467 | .. | .. | |
| No. 3— 5 " | .. | 0.188 | .. | .. | |
| No. 4— 6 " | .. | 0.130 | .. | .. | |
| No. 5—11 " | .. | 0.305 | .. | .. | |
| No. 6—17 " | .. | 0.281 | .. | .. | |
| No. 7— 9 " | .. | 0.409 | .. | .. | |

[1] Calculated on soil dried at 100° C.

0.140. Then, referring to the results obtained in the wheat-field itself, it is seen that after growing wheat with full mineral and nitrogenous manure since 1843-44, the percentage of nitrogen in the dry sifted surface-soil was—in 1865, 0.1230, and in 1881, 0.1264; but with mineral manure without nitrogen, it was—in 1865, only 0.1119, and in 1881, 0.1012 per cent; and lastly, without manure from the commencement it was—in 1865, only 0.1090, and in 1881, 0.1045 per cent. That is to say, with mineral and nitrogenous manure, the percentage of nitrogen was the highest, and rather higher at the later than at the earlier date; the result being due, as has been proved, not to the accumulation of manure-residue, but of crop-residue. On the other hand, with mineral manure without nitrogen, or without any manure at all, the percentage of nitrogen was lower than when nitrogenous manure was also used, and in each case it was lower at the later date—that is, as the exhaustion progressed.

On a consideration of these various results, it may perhaps fairly be concluded that the percentage of nitrogen in the surface-soil of the wheat-field at the commencement was certainly higher than in 1865 or 1881, under the conditions of nitrogen-exhaustion with mineral manure alone, or without any manure at all; and that it was about as high as where nitrogenous as well as mineral manure had been annually applied; probably, therefore, from 0.1250 to 0.1300 per cent, and probably nearer the lower than the higher figure.

Looking to the other results in the table relating to Rothamsted soils, it is seen that with barley, as with wheat, when grown year after year with mineral manures alone, the percentage of nitrogen in the surface-soil was low, with a tendency to decline from time to time; and lastly, after roots grown with mineral manure alone, the percentage is lower still—indeed lower than has been found where any other crop has been grown under similar conditions. Then it is further seen, that in the case of various arable fields laid down to permanent grass, the percentage of nitrogen increased more or less according to the time it had been laid down—the figures at the different periods being 0.1235, 0.1509, 0.1740, 0.2057, and 0.1943; whilst the percentage in very old grass-land was 0.2466.

Next, in various arable soils in Great Britain, the percentage of nitrogen in the surface-soils ranged from 0.107 to 0.220. Compared with these, the percentage in various United States and Canadian prairie soils ranged from 0.187 to 0.618; the greater number showing about 0.30 per cent. Lastly, a num-

ber of Russian soils ranged in percentage from 0.130 to 0.607. It is further seen that the percentages of carbon, and the amount of carbon to 1 of nitrogen, are higher in the grass-land than in the arable soils, and higher still in the rich prairie soils.

*Grass-land, rich, arable land, poor in nitrogen and carbon.*

From these various results there can be no doubt that a characteristic of a permanent grass surface-soil, or of a rich virgin-soil, is a relatively high percentage of nitrogen and of carbon, and a high relation of carbon to nitrogen. On the other hand, a soil that has been long under arable culture is much poorer in these respects; whilst arable soils, under condititions of known agricultural exhaustion, show a very low percentage of nitrogen and of carbon, and a low relation of carbon to nitrogen.

*Accumulated fertility.*

It has sometimes been maintained that a soil is a laboratory and not a mine. But not only the facts ascertained in our own and in other investigations, but the history of agriculture throughout the world, so far as it is known, clearly show that a fertile soil is one which has accumulated within it the residue of long periods of previous vegetation; and that it becomes infertile as this residue is exhausted. Such accumulations are truly enormous in many of the prairie lands of the American continent; sometimes, indeed, extending to a considerable depth. But, even after the comparatively few years which most of them have been under cultivation, it is alleged by some that they are already showing exhaustion.

*Reduction of yield of wheat from prairie land.*

In view of the facts both as to the percentage of nitrogen, and the annual yield of wheat without manure over 40 or 50 years in the Rothamsted experimental field, it is indeed very difficult to believe that the rich prairie lands of the American continent, which yield so large a proportion of the wheat exported from the United States and Canada, can in so much less a time have become exhausted of available nitrogen. Thus it is probable that at the commencement the surface-soil of none of these lands contained less than twice, and few of them less than three times, as high a percentage of nitrogen as the Rothamsted wheat-field soil; whilst frequently the subsoils would, to a considerable depth, be richer than the Rothamsted surface-soil. Yet it is estimated that over a period of 40 years, from 1852 to 1891 inclusive, the produce of the Rothamsted soil without manure has only reduced by an average of about $\frac{1}{8}$ bushel per acre per annum due to exhaustion, irrespectively of fluctuations due to season; and when we consider how much shorter a time most of the rich prairie lands have been growing wheat without manure, it seems that some other reason than exhaustion must be found for their alleged reduction in yield.

As to the number of years during which the greater portion of the rich prairie lands of America have been broken up for the growth of wheat, it may be observed that a series of unproductive seasons, not only in our own country but in Western Europe generally, which culminated in 1879, but continued for some years later, led to a more rapid reduction in our own area under the crop, and concurrently to the opening up of large wheat-growing areas in various parts of the world, and at the same time to greatly increased imports; a much larger amount coming from the United States than from any other country, indeed generally more than from all other countries put together. Thus, the area under wheat in the United States increased from under 21 million acres in 1872, to more than 27½ million in 1876, with an average for the 5 years of nearly 24½ million. Over the next 5 years the area increased from 26¼ million in 1877 to 37¾ million in 1881, with an average over the 5 years of 33⅓ million. Over the next 10 years, from 1882 to 1891, the area averaged 37⅓ million acres; and it was 39.9 million in 1891, and more than 38½ million in 1892.[1] There was an increase, therefore, from less than 21 million in 1872, to an average of 37⅓ million over the 10 years ending 1891, or by about 79 per cent. In fact, this great increase in the area under the crop took place within a period of about 20 years; the actual increase during that period amounting to about 16½ million acres, by far the greater proportion of which was rich prairie land. Of this the larger proportion was brought under cultivation within a period of about 15 years. Bearing in mind the results obtained at Rothamsted without manure for 50 years, on a comparatively very poor soil, it does indeed seem incredible that a period of about 15 years should be sufficient to bring about palpable exhaustion of the incomparably richer prairie soils.

*United States wheat production and export.*

Within the same period of 20 years, the home consumption of wheat in the United States, according to the records, increased from rather under 200 million Winchester bushels in 1872-73, to an average of nearly 334 million over the 10 years from 1882-83 to 1891-92; whilst the exports have increased from 52½ million bushels in 1872-73 to an average of 146½ million over the 5 years 1877-78 to 1881-82; but they amounted to an average of rather less than 130 million over the 10 years 1882-83 to 1891-92. The maximum amount in any one year was, however, 227½ million in 1891-92.

It has been estimated that, judging from the increase of

[1] Subsequent records show that the area was reduced to 34.6 million acres in 1893, and to 34.8 in 1894.

the population of the United States in the past, the Central, Northern, and Western States, from which we now derive such large supplies of grain, will, before many years have passed, be as densely populated as the Eastern States are now; and that then the export of grain will be rapidly diminished. In this calculation, however, the essential difference in the character of the land in the Eastern States, and in the prairie districts of the Central, Northern, and Western States, is not taken into account. It is true that both western meat and western wheat are materially reducing the production of them in the Eastern States; so that the population of the east as well as of the west will consume more and more of the western produce, leaving of course the less for export. And if, in addition to this, it be true, as alleged, that the western lands themselves are losing their fertility, there would indeed seem that there is some likelihood of material reduction in exports before very long.

Certain it is, however, that large areas of formerly prairie land, which provide so much of the exports, were originally as rich as ploughed-up old grass-land in our own country, and sometimes so to a considerable depth. Hitherto the land has, as a rule, only been skimmed, practically no labour bestowed on cleaning, and compared with the produce which such lands should yield if properly cultivated, very small crops of grain have been obtained. But the large crops occasionally yielded under favourable conditions are evidence of the inherent fertility, and of the possible productiveness, of the soil. Further, from what has been said, it is almost impossible to believe that such soils can have become seriously exhausted within comparatively so few years, at any rate so far as available nitrogen is concerned. Indeed, if there be palpable exhaustion at all, it would seem more likely that it is of some mineral constituents—potash, lime, or phosphoric acid, for example. However this may be, so long as wheat is grown under the conditions frequent, and indeed almost inevitable, in the case of new settlement, with sparse population—that is, growing it for several years in succession, with deficient cultivation, luxuriance of weeds, the burning of the straw, and generally the wasting of the manure of the working stock—only low yields can be expected. The practice naturally results from the fact that, under such conditions, fertility is cheap and labour dear. As population becomes more dense, however, local markets will arise for rotation products, more stock will be kept, the straw and the manure will be utilised, cultivation will be improved, and weeds will lose their ascendency. Nor can there be much doubt that under such conditions it will be

found that the growth of comparatively small crops of wheat, even with a fair share of weeds, for 15 or 20 years on rich prairie land has not exhausted its fertility. There will besides, for some time to come, be more rich prairie land to bring under the plough. Upon the whole, it seems probable that, with the improved methods which should result from increased density of population, and with the increased areas brought under cultivation, it will be longer than is sometimes supposed before the capability of the United States of production for export will be materially diminished. Obviously, somewhat similar arguments are, *mutatis mutandis*, applicable to Canada. As, however, the resources of the rest of the world, taken as a whole, show no signs of diminution, it may be a question how far the range of prices will affect the production in any particular country.

## *SECTION V.—ROTATION OF CROPS.*

### Introduction and Historical Sketch.

In the preceding sections attention has been devoted to the consideration of the influence of exhaustion, manures, and variations of season, on the amounts of produce, and on the composition, of certain individual and typical crops when each is grown separately year after year on the same land. In this way there have been discussed the characteristic requirements and results of growth of various cereal crops as representatives of the natural order Gramineæ; of various root-crops of the orders Cruciferæ and Chenopodiaceæ; and lastly, of various Leguminous crops.

Our subject now is the—*Rotation of Crops.* The mere numerical results of the field experiments made at Rothamsted on rotation have been recorded in the annual 'Memoranda'; but the first systematic discussion, either of them or of the laboratory investigations undertaken in connection with them, is that given in this paper, in this volume, and in the *Journal of the Royal Agricultural Society of England* (December 31, 1894); and although the present communication embodies a good deal of detail, and a somewhat comprehensive consideration of it, there still remains much which could not be included within the limits of this paper.

*Importance of rotation.*

The practice of Rotation is admitted to be the foundation of the improvements in our own agriculture which have taken place during this and a considerable part of the last century. It is of great importance, therefore, carefully to consider, both

in what the practice itself consists, and how its benefits are to be explained.

*Rotation crops.* If the rotation of crops as followed in our own country, indeed over large portions of Europe, were to be defined in the fewest possible words, it might be said that it consists in the alternation of root-crops, and of leguminous crops, with cereals. In the United States, however, it is a gramineous crop—maize—which largely takes the place of root-crops in Europe.

*Persistent corn-growing.* The cereals constituting such a very important element of human food, it was natural that they should be grown almost continuously so long as the land would yield remunerative crops. Hence, the history of agriculture, not only in our own country, but in others where these crops were of high relative value, shows that it very generally came to be the custom to grow them for a number of years in succession, and then to have recourse to bare fallow; or, in some cases, to abandon the land to the growth of rough and weedy herbage, affording scanty food for domestic animals.

*Leguminous crops in early rotations.* The improvement upon these practices, attainable by alternating other crops with the cereals, was very much earlier recognised in the case of the leguminous than of the root-crops, the introduction of which is of comparatively recent date.

It was, in fact, distinctly recognised by the Romans more than two thousand years ago, not only that certain leguminous crops were valuable as food for animals, but that their growth enriched the soil for succeeding crops—in fact, that they were of value as restorative crops grown in alternation with the cereals. There is, however, very scanty indication that root-crops were an element in their alternate cropping.

As in the agriculture of the ancients, so in that of more modern times, especially in our own country, various leguminous crops were grown in alternation with cereals long before roots were so interpolated.

*Introduction of turnip-culture.* It was, indeed, not until about, or after, 1730 that Lord Townshend, who, as Secretary to George I., had been in Hanover, and there seen turnips growing as a field crop, on his return introduced them on his own estate in Norfolk, and there founded the celebrated Norfolk four-course rotation of turnips, barley, clover, and wheat. His own land was previously to a great extent a marshy or sandy waste, and its value was increased enormously under the new system. It was, however, not until towards the end of the century that it became generally adopted even throughout his own county. In this extension Mr Coke, of Holkham (afterwards Earl of Leicester), was largely instrumental, and the practice seems to have next extended into Lincolnshire.

It was thus that *The Four-course Rotation*, or, in other words, the alternation of root-crops and of leguminous crops with cereals, became established. Such alternation is, in fact, the basis of all the various rotations which are adopted in different parts of our own country, and also to a great extent which are followed in many other countries. *Four-course rotation.*

It is worthy of remark that, although we owe the introduction of the essential elements of our rotations to the example of our Continental neighbours, we, with one or two immaterial exceptions, obtain more per acre of all the staple saleable products of rotation, grain and meat, under our landlord, tenant, and labourer system, than any other country in Europe, or than in America, under whatever advantages of climate, or under whatever system of holding, or of size of holdings. Thus, there is not a single country in Europe that reaches our average produce per acre of wheat; only Belgium and Holland approach, but they do not equal, us in the produce of barley; only Belgium, Holland, and Norway exceed us in acreage yield of oats; and no country approaches us in acreage produce of potatoes. Again, whilst several countries exceed us in number of cows to a given area, and some in the number of pigs, not one equals us in weight per acre of other cattle than cows; and not one nearly approaches us in the weight of sheep to a given area. Nor, notwithstanding the great depression of our agriculture in recent years, the result of the low prices of produce, is there any probability that we shall soon lose our pre-eminence in production per acre. *Yield of crops in Britain and foreign countries.*

There can be no doubt that the effect of the extension of the growth of green crops was—to a great extent to get rid of unprofitable fallows, greatly to increase the supply of stock food, especially for winter feeding; so to lead to a largely increased production of meat and milk, to a greatly increased supply of manure, and thus to enrich the land for the growth of grain, which, accordingly, yielded much larger crops. *Beneficial influence of green crops.*

We have now to endeavour to ascertain how the admittedly very beneficial effects of alternate, as distinguished from continuous, cropping are to be explained. It will be well first very briefly to refer to some of the chief theoretical explanations that have been put forward, and afterwards to discuss the results of various direct experimental investigations conducted at Rothamsted on the subject of rotation. *Benefits of rotation explained.*

The first definite theory as to the benefits of the alternation of crops assumed that the excreted matters of one description of crop were injurious to plants of the same description, but that they were not so, and might even be beneficial, to other kinds of plants. *Theoretical explanations.*

*Liebig's view.* At first Liebig pronounced this theory of rotation to be the only one having any really scientific basis. Later he seems to have modified his view considerably, and to have supposed that the explanation was—not that the excreted matters of one description of plant were injurious to another of the same description, but that, as the different plants had such very different mineral requirements, the alternation of one kind with another relieved the soil from exhaustion. In his latest work, however, after many years of controversy, he obviously more fully recognised that nitrogen probably played some important part in the matter.

*Boussingault's investigations.* More than fifty years ago Boussingault published the results of an investigation, extending over a period of ten years, to determine the chemical statistics of some of the rotations actually followed in his own locality, in Alsace; and he came to the conclusion that the difference in the amounts of nitrogen taken up by the different crops constituted a very important element in the explanation of the benefits of rotation.

*Professor Daubeny's researches.* We can only further briefly refer to the results and conclusions of the late Professor Daubeny, of Oxford, who commenced a series of experiments in the Botanic Garden there in 1834. One of the original objects he had in view was to test the truth of De Candolle's theory that the excretions of one description of plant were injurious to plants of the same description. He soon came to a negative conclusion on the subject; and recognised the validity of Boussingault's argument, that the actual facts of vegetation in different parts of the world conclusively showed that the same description of plant may continue to grow healthily on the same land for long periods of time. On this point it is scarcely necessary to add that the experience at Rothamsted on the growth of various agricultural crops year after year on the same land for many years in succession is conclusive against the theory of injurious or poisonous excretions.

*Theory of poisonous excretions disproved.*

*Rotation and organic and inorganic constituents.* But, as already said, Dr Daubeny continued his experiments for ten years; and although, in accordance with the prevailing ideas of the time, all his analytical results related to the mineral constituents of his soils and crops, his main conclusion was, that the benefits of rotation were probably as much connected with the available supply of the organic as of the inorganic constituents.

What, then, are the indications of the results of many years of investigation of the subject, in the field and in the laboratory, at Rothamsted?

## THE EXPERIMENTS ON ROTATION MADE AT ROTHAMSTED.

The experiments have been conducted in Agdell Field. An area of $2\frac{1}{2}$ acres is devoted to the purpose. The ordinary four-course rotation of—turnips, barley, clover (or beans), or fallow, and wheat, was adopted. The experiments were commenced in 1848, so that the eleventh course of four years each was completed with the harvest of 1891; and the wheat which has just been sown (October 1894) is the fourth crop of the twelfth course, and will complete the forty-eighth year of the experiments.

The area of $2\frac{1}{2}$ acres was divided into three main divisions, which have, respectively, been under the following conditions as to manuring:—

*Manures used in rotation experiments.*

1. Without manure from the commencement.
2. For the first nine courses, manured with superphosphate alone, applied only for the turnip crop commencing each course; that is, once every four years. For the tenth, and each subsequent course, salts of potash, soda, and magnesia, have been applied as well as superphosphate.
3. A complex artificial manure, also applied every fourth year; that is, for the turnips commencing each course. This manure comprises—superphosphate, salts of potash, soda, and magnesia, ammonium-salts, and rape-cake; and it supplies about 140 lb. of nitrogen per acre for the four years' course; that is, an average of 35 lb. of nitrogen per acre per annum.

The complex manure (3) was designed to be, in great measure, a substitute for farmyard manure; and it was used instead of it, in order that the amount of the different constituents supplied might be more accurately known than would have been the case if farmyard manure had been employed.

*Removal and consumption of roots.*

It should be further explained, that when the land is under turnips, the roots, with their leaves, are removed from one half of each of the three differently manured plots; whilst, on the other half of each, the produce is consumed on the land by sheep; or, if the weather be unsuitable for this, the roots are sliced, and both roots and leaves are spread on the land. Thus, each of the three main divisions is divided into two, making, so far, six in all.

Then again, after the first course of four years, in the third year of each course the leguminous crop was grown on only half of each of the three differently manured plots, and the other half was left fallow. Lastly, as clover cannot be relied upon on such land so often as once in four years, beans have frequently been grown instead.

We have finally, therefore, twelve plots instead of only

three. That is to say, each of the three differently manured plots is divided into four as above described, and as indicated in the heading of the several tables; and, as the same form of table will, as far as possible, be adopted throughout, it is very desirable that a clear idea of the arrangement should be formed at the outset. It will be seen that under each of the three main divisions designated in the heading according to the manuring, the results are subdivided, showing first the produce obtained where the roots were carted from the land; and secondly, where they were fed (or left) upon it. Lastly, under each of these two conditions so far as the disposal of the turnips is concerned, there is again a subdivision into two—one where in the third year of the course the land was left fallow, and the other where either clover or beans was grown.

*Arrangement of plots.*

*Method of ascertaining results.*

Each year the amount of produce on each of the various plots is weighed; samples of each crop are taken; in all the dry substance and the mineral matter (ash), and in many the nitrogen, are determined; in many cases also complete analyses of the ashes of the crops have been made. Lastly, determinations of the total nitrogen have been made in the surface soils, and in the upper layers of the subsoils, at different periods; and the nitrogen as nitric acid has also been determined to a considerable depth. As to the results themselves, only brief reference to the main indications of these various investigations can be made.

*Description of tables.*

Tables 56, 57, 58, and 59, give the amounts of produce of the turnips, the barley, the leguminous crops, and the wheat, respectively, in each of the eleven years in which each was grown, in the eleven completed courses. Each table is divided into three main divisions—the upper one giving the roots, or the grain, &c., as the case may be; the middle the leaves, or the straw; and the lower one the total produce—roots and leaves, or grain and straw, together.

## *The Swedish Turnip Crops.*

*Table 56 explained.*

Referring to Table 56, relating to the Swedish turnips, it is seen that in the first year, 1848, there was, both without manure and with superphosphate alone, much more produce than in any subsequent year; showing that, at the commencement, the land was in somewhat high condition, due to previous treatment. Then, again, as already said, for the tenth and eleventh courses, salts of potash, soda, and magnesia were used as well as superphosphate. For these reasons, the results of the first and of the tenth and eleventh courses are excluded from the averages to which attention will chiefly be

TABLE 56.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS, OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 11 courses, 44 years, 1848-1891.

1.—ROOTS—SWEDISH TURNIPS.

| Years. | Unmanured. | | | | Courses 1-9 superphosphate only. Courses 10 and 11 mixed mineral manure. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. |
| | **ROOTS.** | | | | | | | | | | | |
| | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt | tons cwt |
| 1848 | 8 15¼ | 3 5½ | 8 17¾ | 5 9 | 14 12 | 11 5¾ | 17 5 | 11 0¾ | 19 14¾ | 10 18 | 21 9 | 11 9 |
| 1852 | 1 17 | 1 6 | 1 7¼ | 0 19½ | 12 16¾ | 11 3¼ | 13 13¼ | 12 10¼ | 20 8¼ | 19 10½ | 19 10¾ | 19 6 |
| 1856 | 2 5½ | 1 12 | 1 14 | 1 0¼ | 8 10½ | 6 16 | 9 13¾ | 9 16 | 16 8¼ | 16 13¾ | 16 19¼ | 17 1¼ |
| 1860 | 0 1¾ | 0 1 | 0 1½ | 0 1 | 1 13¾ | 1 9¼ | 2 0¾ | 1 18¾ | 4 7½ | 4 7½ | 4 7 | 3 12 |
| 1864 | 0 7½ | 0 8¾ | 0 9 | 0 8½ | 2 12¾ | 3 8 | 3 19½ | 3 18¾ | 9 2½ | 8 16¼ | 9 5½ | 8 8½ |
| 1868 | Crop | failed | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1872 | 2 11⅞ | 1 11½ | 2 9¼ | 1 9½ | 7 2¼ | 8 10⅝ | 8 7½ | 9 10½ | 16 12 | 16 10⅞ | 16 11¼ | 16 10 |
| 1876 | 1 11½ | 0 17¼ | 1 12¼ | 1 1 | 9 11¼ | 9 8¼ | 10 8¼ | 11 5¾ | 15 9¾ | 17 16 | 18 17¼ | 17 10¼ |
| 1880 | 1 12⅝ | 0 14 | 1 18¼ | 1 1 | 11 4 | 9 19½ | 11 18¾ | 11 3¾ | 22 10¼ | 21 19½ | 22 7½ | 22 6¼ |
| 1884 | 0 17⅝ | 0 5 | 1 0¼ | 0 12 | 7 19¾ | 8 13¼ | 8 12½ | 10 6 | 14 18¼ | 14 0¾ | 14 10¼ | 14 0¾ |
| 1888 | 0 15 | 0 2¼ | 1 3 | 0 8 | 7 2⅞ | 10 7⅛ | 8 6 | 12 9¼ | 21 11¼ | 23 12¼ | 21 3¾ | 20 17⅝ |
| Average 8 courses, 1852 to 1880 | 1 6 | 0 10⅝ | 1 4 | 0 15⅞ | 6 14⅛ | 6 6⅞ | 7 10¼ | 7 10½ | 13 2⅜ | 13 6⅛ | 13 9¾ | 13 2⅞ |
| Average 2 courses, 1884 and 1888 | 0 16½ | 0 3⅝ | 1 1⅝ | 0 10 | 7 11⅜ | 9 10¼ | 8 9¼ | 11 7⅝ | 18 4¾ | 18 19¾ | 18 0 | 17 9¼ |
| | **LEAVES** | | | | | | | | | | | |
| 1848 | 0 19¾ | 2 5¾ | 1 0½ | 3 7¾ | 1 15 | 5 0¼ | 1 19¾ | 4 10 | 2 6¼ | 7 11¾ | 2 0¾ | 1 1¼ |
| 1852 | 0 5¾ | 0 4¼ | 0 4 | 0 3¼ | 1 2¾ | 1 0¼ | 1 2¼ | 1 2 | 2 0 | 1 16½ | 1 17¾ | 1 13 |
| 1856 | 0 2¼ | 0 2½ | 0 2 | 0 1½ | 0 8 | 0 7½ | 0 12¼ | 0 14½ | 0 11½ | 0 12½ | 0 12½ | 0 11¾ |
| 1860 | 0 0⅛ | (6¼ lb.) | 0 0¼ | (5 lb.) | 0 2 | 0 1½ | 0 2 | 0 1¾ | 0 3½ | 0 3½ | 0 5¾ | 0 4½ |
| 1864 | 0 0¾ | 0 0¾ | 0 0¾ | 0 1 | 0 4½ | 0 4¾ | 0 5¼ | 0 4¾ | 0 9 | 0 8¾ | 0 9½ | 0 5 |
| 1868 | Crop | failed | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1872 | 0 8⅛ | 0 8¾ | 0 7¼ | 0 7¾ | 0 14⅝ | 0 17⅜ | 0 17⅜ | 0 19½ | 1 14¼ | 1 15¾ | 1 13½ | 1 10 |
| 1876 | 0 5¼ | 0 5 | 0 5⅛ | 0 5 | 0 17 | 1 8½ | 0 16½ | 1 7½ | 1 14¾ | 2 15¼ | 2 0¾ | 3 3 |
| 1880 | 0 3⅞ | 0 2¼ | 0 4 | 0 3 | 0 12½ | 0 11¾ | 0 12⅞ | 0 11 | 1 16 | 2 3¼ | 1 18 | 1 18¾ |
| 1884 | 0 7⅜ | 0 3¼ | 0 7 | 0 5 | 0 18½ | 1 0¼ | 0 18¾ | 1 3 | 2 15¼ | 3 3¼ | 3 6¼ | 3 3¼ |
| 1888 | 0 7⅛ | 0 1⅞ | 0 7⅞ | 0 3¼ | 0 15½ | 1 1½ | 0 16 | 1 3 | 1 17⅞ | 2 5¾ | 1 15 | 2 0½ |
| Average 8 courses, 1852 to 1880 | 0 3¼ | 0 3 | 0 2⅞ | 0 2⅝ | 0 10⅛ | 0 11½ | 0 11 | 0 12⅝ | 1 1⅛ | 1 4⅜ | 1 2¼ | 1 4⅞ |
| Average 2 courses, 1884 and 1888 | 0 7¼ | 0 2¼ | 0 7¼ | 0 4⅛ | 0 10⅞ | 1 0⅞ | 0 17⅝ | 1 3 | 2 6½ | 2 14½ | 2 10⅝ | 2 12⅛ |
| | **TOTAL PRODUCE.** | | | | | | | | | | | |
| 1848 | 9 15 | 5 11¼ | 9 18¼ | 8 16¾ | 16 7 | 16 12 | 19 4¾ | 15 10¾ | 22 1 | 18 9¾ | 23 15¾ | 19 0¼ |
| 1852 | 2 2¾ | 1 10¼ | 1 11¼ | 1 2½ | 13 19½ | 12 3½ | 14 15½ | 13 12¼ | 22 8¼ | 21 13 | 21 8½ | 20 19 |
| 1856 | 2 7¾ | 1 14½ | 1 16 | 1 1¾ | 8 18½ | 7 3½ | 10 6 | 10 10½ | 16 19¾ | 17 6¼ | 17 11¾ | 17 13 |
| 1860 | 0 1⅞ | 0 1 | 0 1¾ | 0 1 | 1 15¾ | 1 10¼ | 2 2¾ | 2 0½ | 4 11 | 4 10¾ | 4 12¾ | 3 16½ |
| 1864 | 0 8¼ | 0 9½ | 0 9¾ | 0 9½ | 2 17¼ | 3 12¾ | 4 4¾ | 4 3½ | 9 11½ | 9 5 | 9 15 | 8 17¼ |
| 1868 | Crop | failed | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 1872 | 3 0 | 2 2⅞ | 2 16½ | 1 17¼ | 7 16⅞ | 9 8 | 9 4⅞ | 10 10 | 18 6¼ | 18 15⅝ | 18 4¾ | 18 9 |
| 1876 | 1 16¾ | 1 2¼ | 1 17⅜ | 1 6 | 10 10¼ | 10 16¾ | 11 4¾ | 12 13¼ | 17 4½ | 20 11¼ | 20 18 | 21 2¼ |
| 1880 | 1 16½ | 0 16¼ | 2 2¼ | 1 4 | 11 16½ | 10 11¼ | 12 11⅝ | 11 14¾ | 24 6¼ | 24 2¾ | 24 5¼ | 24 5 |
| 1884 | 1 5¼ | 0 6⅛ | 1 7¼ | 0 17 | 8 18¼ | 9 13½ | 9 11¼ | 11 9 | 17 13¾ | 17 10 | 18 2½ | 17 4½ |
| 1888 | 1 2⅛ | 0 4⅛ | 1 10⅝ | 0 11¼ | 7 15⅛ | 11 8⅝ | 9 2 | 13 12¼ | 23 9⅛ | 25 18½ | 22 18¾ | 22 18⅛ |
| Average 8 courses, 1852 to 1880 | 1 9¼ | 0 19⅝ | 1 6⅞ | 0 17¾ | 7 4¼ | 6 18⅜ | 8 1¼ | 8 3⅛ | 14 3½ | 14 10½ | 14 12 | 14 7¾ |
| Average 2 courses, 1884 and 1888 | 1 3¾ | 0 6⅛ | 1 8⅞ | 0 14⅛ | 8 8¼ | 10 11⅛ | 9 6⅝ | 12 10⅝ | 20 11¼ | 21 14¼ | 20 10⅝ | 20 1⅜ |

confined. In this table, however, as well as in those relating, respectively, to the barley and the wheat, averages are given at the foot of each division of the tables, not only for the eight intermediate courses—second to ninth, but also for the two succeeding courses—tenth and eleventh, for which potash, soda, and magnesia were used as well as superphosphate. But, for the leguminous crops, the averages are, for reasons that will be explained, taken differently.

*Variation with seasons.* The first point to notice in the results is that, under each condition as to manuring, there is very great variation in the amount of produce from year to year according to the seasons. Thus, in 1868, the crop entirely failed on all the plots, although seed was sown twice. Again, whilst the complex manure containing nitrogen yielded more than 22 tons of roots in 1880, the same manure gave little more than 4 tons in 1860; the average yield over the eight courses being about 13¼ tons. Against this, the average by superphosphate alone ranged from about 6½ to about 7½ tons; whilst without manure there was an average of only about 1 ton.

*No manure.* Referring to this last result, it is particularly to be observed that this assumed restorative crop yields practically no produce at all when grown without manure.

*With superphosphate.* The plot with superphosphate alone gives very much more than that without manure, but still very much less than an average agricultural crop. The increase, such as it was, was largely due to the greatly increased development of feeding-root within the surface-soil under the influence of the phosphatic manure; and the necessary nitrogen, beyond the small amount of combined nitrogen annually coming down in rain and the minor aqueous deposits from the atmosphere, has doubtless been gathered under the influence of the increased root-development from the previous accumulations within the soil itself. There is, in fact, perhaps no agricultural practice by which what is termed the *condition* of land, that is the readily available fertility due to recent accumulations, can be so rapidly exhausted as by growing turnips on it by superphosphate alone—provided, of course, that the seasons are favourable.

*Mixed manure.* Compared with the produce with superphosphate alone, the mixed manure, supplying, besides superphosphate, not only salts of potash, soda, and magnesia, but a liberal amount of nitrogen, yielded, on the average of the eight courses, nearly twice as much, or between 13 and 14 tons of roots; though, as already pointed out, it yielded in some seasons over 20 tons per acre.

*Nitrogen for turnips.* There can be no doubt that, the necessary mineral constituents being available, there was a large increase of produce due to the supply of nitrogen in the manure.

The figures in the middle division of the table show that the produce of leaf as well as that of roots was increased by superphosphate, and that it was still further increased by the mixed manure containing nitrogen.

*Effects of consuming roots on land.*

The next point is to consider the effects of the other conditions besides those of different manure supply; that is, the removal of the root-crop, or the feeding or the spreading of it upon the land; also whether, in the third year of each course, a leguminous crop was grown, or the land was fallowed.

It is seen that, *without manure*, whether clover or beans were grown, or the land were fallowed, there was even rather less average produce of roots over the eight years where they had been fed on the land, than where they had been carted off; but with such very small crops the differences are immaterial, if not accidental.

On the *superphosphate* plots, where the produce was much higher, and where there would, therefore, be more loss to the land by removal, the crops were materially better on the fed portions of the plots.

On the *mixed manure* plots, on the other hand, with nearly twice as much produce as with superphosphate alone, there would be still greater difference between the condition of the land where the roots were carted off and where they were fed on; but there was very little difference in the average produce of the root-crop.

It will be seen further on, that the higher condition of the land where the more highly manured roots were fed upon it had a very marked effect on the succeeding cereal crops, and especially on the immediately succeeding barley. This was the case on both the superphosphate and the mixed manure plots.

*Effects of fallowing and growing beans and clover.*

The difference of effect on the average produce of the root-crop, by fallowing, or by growing beans or clover, in the third year of each course is, in the comparable cases, practically immaterial under each of the three different conditions as to manuring.

*Influence of season.*

Before passing from Table 56 it is to be observed that there was higher average produce over the tenth and eleventh courses with superphosphate and potash, soda, and magnesia, than over the preceding eight courses with superphosphate alone. But, as there was also increase in a greater degree with the mixed mineral and nitrogenous manure over the two than over the eight years, it is obvious that the character of the seasons had a good deal to do with the result. It is noticeable, however, that on the plots with potash, soda, and magnesia, as well as superphosphate, in the two courses, there was a higher produce of roots on the plots where beans or

*Legumes and accumulation of nitrogen.*

clover were grown than on those that were fallowed, a result doubtless due to the increased growth of the leguminous crop under the influence of the potash manuring, and to accumulation of nitrogen in the soil thereby. It may further be observed (though not shown in the table) that in 1892—that is, the first year of the twelfth course—the produce of the manured plots was generally higher than in either of the two preceding courses.

The accompanying figures represent selected typical Swedish turnip-plants, grown in 1892—(1) without manure, (2) with

1. Crop of roots, 1892 [illegible] cwts per acre

2. Crop of roots, 1892 11 tons 6¼ cwts per acre

Crop of roots, 1892 24 tons 18 cwts per acre

*Illustrations of plants.*

the mixed mineral manure alone, and (3) with the mixed mineral and nitrogenous manure. Each plant was fixed upon a scaled background and so photographed, and the figures as given are about one-twentieth natural size, and strictly comparable. The quantities of produce recorded show that without manure it was less, but that by each of the two descriptions of manure it was considerably more, than the average of the preceding courses; and both the reversion to the uncultivated condition without manure, and the increased

growth under the influence of each of the manures, are strikingly illustrated, both by the figures and by the amounts of produce given. Indeed, the results conclusively show how artificial a product is the cultivated root-crop, and how dependent it is for its successful growth on an abundant supply of available food—nitrogenous as well as mineral—within the soil.

*Abundance of available food essential for turnips.*

## *The Barley Crops.*

Table 57 (p. 206) gives the produce of barley, the second crop of the course, and therefore always succeeding the roots, in each of the eleven years in which it was grown, in precisely the same form as that of the Swedish turnips recorded in Table 56: the upper division giving the grain per acre, the middle division the straw, and the lower one the total produce, grain and straw together.

*Table 57 explained.*

As in the case of the root-crops, so in that of the barley, the produce in the first course is excluded from the calculation of the averages to which reference will chiefly be made. Indeed, the results of the first year of barley confirm the conclusion that the land was in somewhat high condition due to recent accumulations. The produce of the tenth and eleventh courses is also excluded from the averages, on account of the change of manure on the superphosphate plot for the tenth and succeeding courses.

Referring, however, first to the results of each of the eleven years, it is seen that, under each condition of manuring, or other treatment, there is very great variation in the amount of produce from year to year, due to variations in the characters of the seasons. Thus, without manure, the average produce over the eight courses was about 30 bushels per acre, whilst in 1857 it was in each case more than 40 bushels, and in some considerably more; but in 1869 and in 1873 it was not much over 20 bushels, and in the last two courses considerably less than 20. A glance down the columns recording the produce on the manured plots will show that in their case also there was a wide range in amount above and below the averages, according to season.

*Variation with seasons.*

Referring now to the average produce of the eight courses (second to ninth), the first point to notice is, that whilst the assumed restorative crop—the roots—gave practically no produce at all without manure, the barley gave, on land unmanured for so many years, an average of rather over 30 bushels per acre. The truth is that the cultivation for the preceding roots kept the land clean, and as there was practically no produce of roots, the soil was, in point of fact, left almost fallow for the barley during the winter preceding the

*No manure.*

TABLE 57.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 11 courses, 44 years, 1848–1891.

2. BARLEY.

| Years. | Unmanured. | | | | Courses 1–9 superphosphate only. Courses 10 & 11 mixed mineral manure. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. |
| **DRESSED GRAIN.** | | | | | | | | | | | | |
| | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. |
| 1849 | 33¾ | 44⅞ | 44⅞ | 48 | 29⅛ | 29⅞ | 41 | 42¾ | 37 | 28⅞ | 44⅛ | 42⅞ |
| 1853 | 32⅛ | 34⅜ | 33 | 28⅞ | 32 | 25⅝ | 39⅞ | 38 | 37⅞ | 38¼ | 37⅛ | 35⅜ |
| 1857 | 43¾ | 48½ | 44¼ | 40⅛ | 30¾ | 28½ | 48¾ | 52⅝ | 47½ | 48 | 66⅝ | 63⅛ |
| 1861 | 35½ | 38⅝ | 33 | 29⅝ | 32⅜ | 30⅝ | 40⅜ | 42½ | 60⅞ | 60⅝ | 57¾ | 54⅛ |
| 1865 | 34½ | 39 | 35⅛ | 27¾ | 31¼ | 33¼ | 39⅛ | 41¼ | 44⅝ | 47½ | 46⅝ | 43⅝ |
| 1869 | 21⅜ | 24⅝ | 21 | 25⅝ | 25½ | 28¾ | 30⅛ | 33½ | 39¾ | 42⅞ | 38⅜ | 42¼ |
| 1873 | 20¾ | 23½ | 20⅞ | 22⅞ | 22⅛ | 20¾ | 27 | 29⅜ | 31½ | 31¾ | 47 | 45⅛ |
| 1877 | 23 | 23¼ | 22¼ | 23⅝ | 21 | 24¼ | 31⅜ | 38⅜ | 30¾ | 34¾ | 44⅝ | 49⅛ |
| 1881 | 29⅛ | 26½ | 31⅜ | 25⅞ | 24¼ | 24½ | 28⅛ | 28¾ | 33⅜ | 35⅜ | 47⅞ | 50¼ |
| 1885 | 15½ | 12⅛ | 22¾ | 16 | 12⅞ | 19⅞ | 17⅛ | 32½ | 10 | 34¾ | 32¼ | 44¾ |
| 1889 | 15½ | 11 | 16⅞ | 12⅝ | 15⅛ | 21¾ | 19¼ | 29¾ | 20 | 26⅝ | 23½ | 25½ |
| Av. 8 courses 1853–1881 | 30 | 32⅜ | 30⅛ | 28 | 27⅜ | 27⅜ | 35⅝ | 38 | 40¾ | 42⅜ | 48⅜ | 47⅞ |
| Av. 2 courses 1885 & 1889 | 15½ | 11½ | 19¾ | 14⅜ | 14 | 20⅞ | 18¼ | 31⅛ | 19½ | 30¾ | 27⅞ | 35⅛ |
| **STRAW.** | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 1849 | 2200 | 2963 | 3139 | 3225 | 1870 | 2111 | 3209 | 3327 | 2842 | 2088 | 3709 | 3646 |
| 1853 | 2187 | 2430 | 2210 | 2077 | 2003 | 1873 | 2729 | 2756 | 2595 | 2604 | 3323 | 2981 |
| 1857 | 2330 | 2600 | 2430 | 2312 | 1545 | 1475 | 2595 | 2780 | 2400 | 2435 | 3570 | 3405 |
| 1861 | 2190 | 2522 | 2018 | 1970 | 1954 | 2000 | 2475 | 2553 | 3920 | 3940 | 4175 | 3940 |
| 1865 | 1828 | 2154 | 1809 | 1460 | 1509 | 1615 | 2043 | 2244 | 2398 | 2595 | 3274 | 2958 |
| 1869 | 1628 | 1948 | 1648 | 1944 | 1873 | 2025 | 2265 | 2401 | 3064 | 3309 | 3244 | 3229 |
| 1873 | 1374 | 1343 | 1311 | 1495 | 1370 | 1565 | 1611 | 1841 | 1626 | 1723 | 2706 | 2456 |
| 1877 | 1244 | 1291 | 1275 | 1341 | 1054 | 1174 | 1706 | 1994 | 1625 | 1918 | 2646 | 3125 |
| 1881 | 1556 | 1484 | 1568 | 1468 | 1239 | 1259 | 1500 | 1480 | 1755 | 1853 | 2993 | 3078 |
| 1885 | 1518 | 1270 | 1768 | 1579 | 1043 | 1441 | 1480 | 2358 | 1528 | 2461 | 2778 | 3386 |
| 1889 | 953 | 931 | 996 | 865 | 965 | 1221 | 1135 | 1613 | 1281 | 1685 | 1776 | 2030 |
| Av. 8 courses 1853–1881 | 1792 | 1971 | 1784 | 1758 | 1568 | 1628 | 2116 | 2250 | 2423 | 2547 | 3253 | 3146 |
| Av. 2 courses 1885 & 1889 | 1235 | 1101 | 1382 | 1122 | 1004 | 1331 | 1307 | 1986 | 1380 | 2073 | 2277 | 2708 |
| **TOTAL PRODUCE.** | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 1849 | 4149 | 5656 | 5785 | 6046 | 3575 | 3841 | 5708 | 5885 | 5026 | 3794 | 6344 | 6206 |
| 1853 | 4046 | 4464 | 4161 | 3517 | 3876 | 3560 | 5110 | 5058 | 4849 | 4873 | 5672 | 5190 |
| 1857 | 4777 | 5337 | 4912 | 4558 | 3272 | 3076 | 5326 | 5741 | 5091 | 5168 | 7261 | 6930 |
| 1861 | 4248 | 4718 | 3871 | 3635 | 3807 | 3775 | 4803 | 4982 | 7419 | 7391 | 7554 | 7148 |
| 1865 | 3659 | 4182 | 3695 | 2961 | 3170 | 3394 | 4122 | 4457 | 4799 | 5148 | 5753 | 5308 |
| 1869 | 2881 | 3358 | 2843 | 3367 | 3328 | 3686 | 3999 | 4318 | 5414 | 5800 | 5491 | 5701 |
| 1873 | 2596 | 2717 | 2536 | 2844 | 2718 | 2875 | 3209 | 3575 | 3412 | 3573 | 5478 | 5018 |
| 1877 | 2602 | 2628 | 2609 | 2673 | 2304 | 2558 | 3530 | 4157 | 3406 | 3890 | 5217 | 5963 |
| 1881 | 3170 | 2922 | 3297 | 2929 | 2576 | 2641 | 3083 | 3051 | 3651 | 3857 | 5720 | 5964 |
| 1885 | 2402 | 1960 | 3056 | 2235 | 1833 | 2538 | 2576 | 4193 | 2648 | 4426 | 4624 | 5946 |
| 1889 | 1789 | 1510 | 1898 | 1580 | 1775 | 2402 | 2248 | 3250 | 2362 | 3134 | 3045 | 3409 |
| Av. 8 courses 1853–1881 | 3497 | 3790 | 3491 | 3351 | 3131 | 3196 | 4148 | 4417 | 4755 | 4962 | 6018 | 5903 |
| Av. 2 courses 1885 & 1889 | 2095 | 1735 | 2477 | 1882 | 1804 | 2470 | 2412 | 3722 | 2503 | 3780 | 3835 | 4677 |

roots, during the root-crop period itself, and during the succeeding winter, before the sowing of the barley. There was, therefore, very good preparation for the barley. It will be seen further on that, when grown continuously without manure, both wheat and barley yield more in proportion to their respective averages under ordinary cultivation than does either of the fallow crops—the roots or the leguminous crops. Yet, the produce of barley in rotation without manure was much in excess of that when it is grown continuously; the explanation doubtless being, as above referred to, that the crop had been grown after well-cultivated bare fallow.

*Barley in rotation and grown continuously.*

Next, it is to be observed that, there having been practically no crop of roots without manure, there was no material difference between the yield of the succeeding barley where the roots were carted off or where they were fed on the land.

*With superphosphate.*

Turning now to the produce on the four plots with superphosphate alone, it is seen that whilst the average yield of barley on the two portions from which the roots had been carted off was under 28 bushels, that on the portions where they had been fed on the land was, in one case more than $35\frac{1}{2}$, and in the other 38 bushels. The effect on the one hand of the removal of the larger crop of roots, and on the other of the retention on the land of the greater part of its constituents, is thus very evident. It is further to be remarked, that the produce of barley where the roots grown by superphosphate had been removed from the land was even less than on the two corresponding portions of the unmanured plot. Thus, there is confirmation of the supposition that the higher crop of barley without manure was due to the previous preparation, and conservation of constituents, by fallow; and that the lower produce on the superphosphate plot where the roots had been removed was largely due to so much greater exhaustion, especially of the available nitrogen, of the surface soil.

*Mixed manure.*

Next it is seen that, on the plots where the mixed manure containing nitrogen had been applied for the preceding turnips, the produce of barley was on a much higher level; and it was much higher on the portions where the turnips had been fed on the land than on those from which they had been removed.

*Effects of consumption of roots on land.*

It may be observed that the produce, even on the plots with superphosphate alone, was, where the roots had been fed on the land, about the average of the country at large under ordinary rotation—namely, from 36 to 38 bushels; whilst, on the full manured plot, the produce was much more than this—namely, in one case $40\frac{3}{4}$, and in the other $42\frac{5}{8}$ bushels, where the roots had been removed; and where they had

been fed on the land, in one case 48⅝, and in the other 47⅞ bushels.

Thus, then, the effect on the succeeding barley of the full mineral and nitrogenous manure applied for the preceding turnips is very obvious; whilst the effect on the one hand of the removal of the root-crop, and on the other of the retention on the land of most of its constituents, is also very marked. The experimental results relating to the second crop of the course—the barley—so far fully confirm, therefore, the explanations which have been given of the beneficial effects of root-crops grown under the ordinary conditions of manuring, on the succeeding cereal grown in alternation with them.

Examination of the results relating to the quantities of straw, and of total produce (grain and straw together), as given in the middle and lower divisions of the table, will show that they fully bear out the general conclusions that have been drawn from a consideration of the produce of the grain alone.

### *The Leguminous Crops (or Fallow).*

*Table 58 explained.* Table 58 (p. 209) gives for the third element of the typical four-course rotation—the leguminous crops—the results obtained in each of the eleven years of the forty-four in which they were grown, in exactly the same form as those previously recorded for the turnips and for the barley. But as in some of the years clover, and in others beans, were grown, the averages are here taken, not for the eight and for the two courses, as with the other crops, but, respectively, for the four years of the eleven in which clover was grown, and for the seven in which beans were grown.

A glance at the table brings to view some of the difficulties connected with the growth of these crops. Thus, although the scheme of the four-course rotation supposes the growth of red clover as the third crop of each course, that is once in four years, it has in fact only been grown four times in the forty-four years—namely, in the first, seventh, ninth, and tenth courses; and when it failed beans were grown instead.

*Intervals between clover crops.* It is, indeed, a matter of general knowledge and experience, that it is only on a few descriptions of soil that clover can be grown so frequently as every fourth year; and in many cases it is not attempted to grow it more than once in eight years. The difficulty of growing red clover or beans frequently on ordinary arable land has been very fully illustrated in our experiments on the growth of leguminous crops. On the other hand, it has been found that red clover may be grown for many years in succession on rich garden soil; and, further,

TABLE 58.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 11 courses, 44 years, 1848-1891.

3. CLOVER (OR BEANS), OR FALLOW.

| Years. | Unmanured. | | | | Courses 1-9 superphosphate only. Courses 10 and 11 mixed mineral manure. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. |
| BEANS; DRESSED CORN—1854, '58, '62, '66, '70, '78, and '90. (CLOVER—1850, '74, '82, and '86.) | | | | | | | | | | | | |
| | | Bush. | | Bush. | | Bush. | | Bush. | | Bush. | | Bush. |
| 1850 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1854 | | 5⅛ | | 5½ | | 5⅞ | | 10⅝ | | 9⅞ | | 13⅜ |
| 1858 | | 6¼ | | 5⅛ | | 6½ | | 8⅝ | | 12⅜ | | 14¾ |
| 1862 | | 29 | | 27 | | 29¾ | | 30 | | 43⅜ | | 41⅛ |
| 1866 | | 10¼ | | 8¾ | | 7⅜ | | 10 | | 20⅜ | | 24¾ |
| 1870 | | 13⅜ | | 17⅞ | | 15⅝ | | 15⅜ | | 24⅝ | | 26⅝ |
| 1874 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1878 | | 8¾ | | 7⅜ | | 7¾ | | 13⅞ | | 20¼ | | 26⅝ |
| 1882 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1886 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1890 | | 7 | | 8¼ | | 24⅝ | | 24 | | 15¼ | | 16¾ |
| Average 7 courses, beans, 1854, '58, '62, '66, '70, '78, and '90 | | 11⅜ | | 11⅜ | | 13⅞ | | 16⅛ | | 20⅞ | | 23⅜ |
| BEANS; STRAW—1854, '58, '62, '66, '70, '78, and '90. (CLOVER—1850, '74, '82, and '86.) | | | | | | | | | | | | |
| | | lb. | | lb. | | lb. | | lb. | | lb. | | lb. |
| 1850 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1854 | | 1055 | | 953 | | 1103 | | 1378 | | 1355 | | 1605 |
| 1858 | | 1100 | | 965 | | 1155 | | 1320 | | 1520 | | 1760 |
| 1862 | | 1840 | | 1845 | | 2150 | | 2155 | | 3280 | | 2945 |
| 1866 | | 1013 | | 905 | | 978 | | 1835 | | 1990 | | 2155 |
| 1870 | | 738 | | 710 | | 768 | | 878 | | 1056 | | 1008 |
| 1874 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1878 | | 740 | | 775 | | 1045 | | 1350 | | 1655 | | 1880 |
| 1882 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1886 | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) | | (clover) |
| 1890 | | 603 | | 633 | | 1764 | | 1630 | | 1102 | | 1059 |
| Average 7 courses, beans, 1854, '58, '62, '66, '70, '78, and '90 | | 1013 | | 969 | | 1280 | | 1507 | | 1708 | | 1773 |
| CLOVER (AS HAY)—1850, '74, '82, and '86. BEANS (CORN and STRAW)—1854, '58, '62, '66, '70, '78, and '90. | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 1850 | (6440) | (5920) | (7027) | (5413) | (6799) | (6329) | (6739) | (5580) | (7697) | (6920) | (7275) | (6753) |
| 1854 | | 1445 | | 1367 | | 1534 | | 2124 | | 2065 | | 2544 |
| 1858 | | 1515 | | 1307 | | 1605 | | 1895 | | 2357 | | 2754 |
| 1862 | | 3661 | | 3546 | | 4040 | | 4027 | | 5990 | | 5520 |
| 1866 | | 1689 | | 1485 | | 1463 | | 2481 | | 3343 | | 3782 |
| 1870 | | 1591 | | 1854 | | 1778 | | 1867 | | 2664 | | 2748 |
| 1874 | | (2838) | | (2497) | | (5093) | | (6186) | | (7904) | | (7708) |
| 1878 | | 1301 | | 1255 | | 1557 | | 2241 | | 2963 | | 3617 |
| 1882 | | (2935) | | (2492) | | (6700) | | (7927) | | (8882) | | (9374) |
| 1886 | | (1285) | | (1305) | | (4925) | | (4695) | | (3255) | | (3645) |
| 1890 | | 1079 | | 1197 | | 3441 | | 3269 | | 2145 | | 2195 |
| Average 7 courses, beans, 1854, '58, '62, '66, '70, '78, and '90 | | 1754 | | 1716 | | 2203 | | 2558 | | 3075 | | 3308 |
| Average 4 courses, clover, 1850, '74, '82, and '86 | | 3245 | | 2927 | | 5762 | | 6097 | | 6740 | | 6870 |

that on ordinary arable land where clover had entirely failed, some other Leguminosæ, having more extended root range, or more powerful root habit, grew luxuriantly, and yielded large crops, containing large amounts of nitrogen, for a number of years in succession. Lastly, in another field, where beans had frequently failed, red clover was afterwards sown, and gave unusually large crops.

Referring to the results in Table 58, it is seen that when clover was grown in 1850, that is in the first course, and when it had not been grown on the same land for many years, large crops were obtained on all the plots; though the larger where the mixed manure including potash, and also nitrogen, had been applied for the root-crop three years previously. For the second, third, and fourth courses, clover was sown with the preceding barley, but in all three it failed in the winter, and beans were grown instead; that is, in 1854, 1858, and 1862. After these repeated failures, clover was not sown for the fifth and sixth courses, but beans were taken instead, in 1866 and in 1870. In the seventh course, clover was sown again, with the barley, and gave three cuttings in 1874; that is, twenty-four years since the last good crop. Without manure, the produce was, however, not much more than one ton per acre; with superphosphate it was much more; and with the mixed manure, including potash, much more still—corresponding to about $3\frac{1}{2}$ tons of clover hay. For the eighth course clover was not sown, but beans were taken in 1878. For the ninth and tenth courses, however, clover was again sown, yielding in the ninth (1882) even more than in 1874; but in the tenth (1886) very much smaller crops, though more with mineral manure alone, now including potash, than with the mixed manure containing nitrogen also. Lastly, for the eleventh course, clover was again sown with the barley, but failed, and in 1890 beans were grown instead; the crops, as in the case of the clover in the tenth course, being greater with mineral manure alone (now including potash) than with the mixed manure containing nitrogen also.

*Effects of manure on clover and beans.*

*Failures of clover.*

Thus, in only four out of the eleven years in which clover should have been grown, was any crop obtained, and beans had to be taken in the other seven. The produce of clover is given in the lower division of the table, side by side with the total produce (corn and straw) of the *beans;* and the results for the clover are entered in parentheses.

*Summary of yields of clover and beans.*

Briefly to summarise the results given in the table, it may be stated that the average produce of clover, reckoned as hay, was, without manure, rather over 3000 lb.; with the superphosphate (in the last year with potash, soda, and magnesia also) nearly 6000 lb.; and with the mineral and nitrogenous

manures together for each course, about 6800 lb. With the mineral manure alone, therefore, there was about twice as much, and with the mineral and nitrogenous manures together, considerably more than twice as much, as without manure. Compared with these amounts of clover reckoned as hay, the seven bean crops (corn and straw together) gave an average of about 1700 lb. without manure, of nearly 2400 lb. with mineral manure alone, and about 3200 lb. with the mineral and nitrogenous manures together.

Not only, therefore, was the average produce of the bean crop very much less than that of the clover, but in point of fact it was only in one year, 1862, that anything like a really good crop of beans was obtained. It may be added, though the point will be further illustrated presently, that the crops of the four years of clover contained, even without manure, about as much nitrogen as, and with each of the two manures considerably more than, those of the seven years of beans. In fact, the average produce of the bean crop, and of nitrogen in it, was very much less than in the case of the clover. Nevertheless, even the average yield of nitrogen was much more in the beans than in either of the cereals with which they were grown in alternation. Thus, without manure, the four clover crops gave an average of 60.2 lb. of nitrogen per acre, and the seven bean crops 34.9 lb.; but over the eleven courses the barley gave an average of only 28.0 lb., and the wheat of only 31.7 lb. With mineral manure alone, the average yield of nitrogen was, in the clover 119.2 lb., in the beans 49.2 lb., in the barley only 27.7 lb., and in the wheat only 39.3 lb. Lastly, with mineral and nitrogenous manure together, the clover gave an average yield of nitrogen of 134.6 lb., the beans of 64.1 lb., the barley 41.2 lb., and the wheat 43.5 lb. There can, indeed, be no doubt, that the leguminous crops, and especially the clover, growing on land in the same condition, and similarly manured, have the power of taking up much more nitrogen over a given area from some source, than the cereals with which they are interpolated; and that the beneficial effects of the growth of such crops in rotation with the cereals are intimately connected with this capability.

*Nitrogen in legumes and cereals*

*Leguminous crops and soil nitrogen.*

Before passing from the results in Table 58 it may be observed that, both with mineral manure alone, and with mineral and nitrogenous manure together, there is rather more produce, both of the clover and of the bean crop, where the roots had been fed upon the land, than where they had been carted off; that is the higher the condition of the land. Thus, then, the effects of the treatment of the first crop of the course —the roots—on the produce of the third or leguminous crop are clearly shown.

*Leguminous crops and the consumption of roots on land.*

*Leguminous crops as a substitute for fallow.*

As already referred to, in the second and subsequent courses, when the third year came round each plot was divided, clover or beans being grown on one half, and the other half left fallow. We have, therefore, the means of comparing the effects on the other crops of the rotation—of fallow on the one hand, which of course removes nothing (though there may be the more loss by drainage), and of growing beans or clover on the other, a characteristic of which is the assimilation, and consequently the removal in the crops, especially of large amounts of nitrogen, but of other constituents also; at the same time, however, leaving in the land more or less of nitrogenous crop-residue. Such a comparison obviously has a special interest, since it is chiefly as a substitute for fallow that the growth of leguminous crops has been introduced into our rotations.

### *The Wheat Crops.*

Table 59 (p. 213) records the results obtained with the fourth element of the rotation—the wheat—exactly in the same form as in the case of the other crops.

*Variations with seasons.*

Looking first to the figures relating to the individual years, it is seen that, under each condition of manuring or other treatment, there is an enormous variation in the amount of produce in the different years, according to the seasons. Thus, taking for illustration the results in the first column under each of the three main conditions as to manuring, that is where the roots were carted from the land, and where in the third year of the course it was left fallow, there was, without manure, only 10⅛ bushels of wheat in 1879, but 45 bushels in 1863: on the superphosphate plot there was in 1879 only 14¾ bushels, and 46 bushels in 1863; and on the mixed manure plot only 12⅜ bushels in 1879, but 52⅝ bushels in 1863. Or, comparing the quantities of total produce, corn and straw together, which more directly represent the amounts of growth, we have, on the same plots, without manure, 2162 lb. per acre in 1879, and 7446 lb. in 1863; on the superphosphate plot 2905 lb. in 1879, and 7626 lb. in 1863; and lastly, on the mixed manure plot, only 2478 lb. in 1879, but 8837 lb. in 1863.

The cases cited are those of the most extreme fluctuations due to season; but a glance at the columns will show that there were very considerable variations in other years, under each condition as to manuring, or other treatment; whilst the amounts of the variations differ more or less under the different soil conditions. It will be obvious, therefore, that if we would fairly compare with one another the effects of

TABLE 59.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 11 courses, 44 years, 1848–1891.

4. WHEAT.

| Years. | Unmanured. | | | | Courses 1–9 superphosphate only. Courses 10 and 11 mixed mineral manure. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. | Fallow. | Beans or clover. |
| **DRESSED GRAIN.** | | | | | | | | | | | | |
| | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. | Bush. |
| 1851 | 30½ | 28½ | 31¼ | 30⅞ | 31⅜ | 28 | 32⅞ | 32 | 30⅛ | 28⅞ | 27⅛ | 31¾ |
| 1855 | 37⅜ | 35½ | 37¼ | 34¼ | 38⅞ | 35¼ | 37⅝ | 36⅜ | 38¼ | 37⅜ | 37⅜ | 40¾ |
| 1859 | 35¾ | 35¼ | 35½ | 30¼ | 37⅛ | 34¾ | 39⅝ | 37¼ | 42⅜ | 39¾ | 40½ | 38⅞ |
| 1863 | 45 | 34⅛ | 42 | 30½ | 46 | 34⅞ | 49⅛ | 41⅞ | 52⅝ | 46⅕ | 49 | 44⅛ |
| 1867 | 27⅛ | 21 | 23⅜ | 15½ | 26⅛ | 19¾ | 27⅛ | 25 | 22⅜ | 23¾ | 19⅞ | 21¼ |
| 1871 | 14½ | 20⅝ | 14½ | 21⅜ | 16⅛ | 23⅞ | 15⅜ | 23 | 17⅜ | 24 | 17¼ | 25¼ |
| 1875 | 24⅜ | 21⅝ | 24⅛ | 19⅝ | 28⅞ | 28¼ | 30⅝ | 31¾ | 29⅛ | 31⅞ | 30 | 30⅛ |
| 1879 | 10⅛ | 10⅜ | 11¾ | 8⅞ | 14¾ | 14⅜ | 14⅛ | 15⅛ | 12⅜ | 13 | 10⅜ | 14 |
| 1883 | 33½ | 29⅜ | 34¼ | 25¾ | 38½ | 36½ | 40½ | 40 | 37½ | 45⅛ | 39¼ | 50½ |
| 1887 | 34¾ | 25⅝ | 33½ | 27¼ | 41⅝ | 42¼ | 40¼ | 44¾ | 39½ | 42¼ | 41 | 43¼ |
| 1891 | 32 | 29½ | 31¼ | 26½ | 36 | 42¼ | 40 | 50¼ | 41 | 44⅜ | 45¼ | 42 |
| Av. 8 courses 1855 to 1883 | 28½ | 26 | 27⅞ | 23¼ | 30¾ | 28½ | 31¾ | 31⅜ | 31½ | 32⅝ | 30½ | 33¼ |
| Av. 2 courses 1887 and 1891 | 33⅜ | 27½ | 32⅜ | 26⅞ | 38¾ | 42¼ | 40⅛ | 47½ | 40¼ | 43⅜ | 43⅛ | 42⅝ |
| **STRAW.** | | | | | | | | | | | | |
| | lb. | lb. | lb | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 1851 | 3273 | 3431 | 3498 | 3760 | 3497 | 3371 | 3334 | 4014 | 3610 | 3552 | 3969 | 4085 |
| 1855 | 4295 | 3619 | 4070 | 3351 | 4285 | 3525 | 4492 | 3611 | 4952 | 3942 | 5107 | 4370 |
| 1859 | 4315 | 4030 | 4045 | 3355 | 4310 | 3930 | 4720 | 4320 | 5330 | 4610 | 5545 | 4955 |
| 1863 | 4563 | 3468 | 4295 | 3008 | 4690 | 3390 | 5051 | 3888 | 5495 | 4698 | 5638 | 4919 |
| 1867 | 2654 | 2143 | 2598 | 1524 | 2774 | 1966 | 2939 | 2648 | 2850 | 3003 | 2905 | 1654 |
| 1871 | 2075 | 2799 | 1946 | 2655 | 2128 | 3048 | 2240 | 2980 | 2628 | 3440 | 2863 | 3644 |
| 1875 | 2833 | 2430 | 2851 | 2353 | 3230 | 3536 | 3525 | 3928 | 3023 | 4685 | 4085 | 4385 |
| 1879 | 1493 | 1324 | 1612 | 1219 | 1956 | 1771 | 1843 | 1771 | 1691 | 1658 | 1426 | 2138 |
| 1883 | 2994 | 2280 | 3231 | 2060 | 3686 | 3021 | 4110 | 3275 | 3689 | 4024 | 4028 | 4505 |
| 1887 | 2505 | 1859 | 2655 | 1844 | 3465 | 3298 | 3480 | 3468 | 3308 | 3423 | 3763 | 3645 |
| 1891 | 2941 | 2598 | 2898 | 2318 | 3586 | 3995 | 4103 | 5017 | 4288 | 4575 | 4938 | 4300 |
| Av. 8 courses 1855 to 1883 | 3153 | 2762 | 3081 | 2441 | 3383 | 3023 | 3621 | 3303 | 3782 | 3758 | 3950 | 3821 |
| Av. 2 courses 1887 and 1891 | 2723 | 2229 | 2777 | 2081 | 3526 | 3647 | 3792 | 4243 | 3798 | 3999 | 4350 | 3977 |
| **TOTAL PRODUCE.** | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb |
| 1851 | 5290 | 5389 | 5584 | 5855 | 5617 | 5253 | 6062 | 6176 | 5642 | 5500 | 5801 | 6169 |
| 1855 | 6735 | 5859 | 6473 | 5526 | 6756 | 5789 | 6961 | 5921 | 7428 | 6371 | 7499 | 6992 |
| 1859 | 6582 | 6262 | 6270 | 5265 | 6671 | 6120 | 7242 | 6689 | 8066 | 7154 | 8136 | 7417 |
| 1863 | 7446 | 5621 | 6999 | 4941 | 7626 | 5619 | 8194 | 6562 | 8837 | 7627 | 8747 | 7721 |
| 1867 | 4330 | 3473 | 4126 | 2506 | 4420 | 3222 | 4702 | 4242 | 4828 | 4567 | 4180 | 3023 |
| 1871 | 3004 | 4092 | 2840 | 3994 | 3133 | 4521 | 3193 | 4404 | 3747 | 4942 | 3925 | 5236 |
| 1875 | 4412 | 3784 | 4396 | 3642 | 5065 | 5328 | 5443 | 5954 | 5448 | 6699 | 5942 | 6292 |
| 1879 | 2162 | 1987 | 2351 | 1800 | 2905 | 2729 | 2755 | 2781 | 2478 | 2403 | 2100 | 3034 |
| 1883 | 5140 | 4175 | 5445 | 3741 | 6208 | 5400 | 6778 | 5901 | 6132 | 6921 | 6586 | 7743 |
| 1887 | 4689 | 3483 | 4811 | 3550 | 6103 | 5994 | 6105 | 6332 | 5894 | 6103 | 6410 | 6409 |
| 1891 | 4868 | 4371 | 4763 | 3921 | 5742 | 6546 | 6509 | 8034 | 6748 | 7250 | 7610 | 6811 |
| Av. 8 courses 1855 to 1883 | 4976 | 4407 | 4863 | 3927 | 5348 | 4841 | 5658 | 5307 | 5808 | 5847 | 5883 | 5932 |
| Av. 2 courses 1887 and 1891 | 4779 | 3927 | 4787 | 3736 | 5923 | 6270 | 6307 | 7183 | 6321 | 6677 | 7010 | 6610 |

the varying conditions, it is important to take the average results of a sufficient number of years to eliminate the influence of the varying seasons. Most of our illustrations will, therefore, be drawn from the average results over the eight years of wheat in the second to the ninth courses; but some reference will also be made to the averages for the tenth and eleventh courses.

*Effects of manures.*

Let us first compare the average amounts of produce of grain under the three main conditions as to manuring, excluding, however, those obtained on the portion of the unmanured plot where the roots were fed on the land, and where beans or clover were grown in the third year of each course; as the crops, especially of the barley and of the wheat, were somewhat adversely affected by a dell on one side of the plot, the surface-soil being in consequence comparatively shallow. The figures show that, on the three portions, the produce ranged, without manure, from 26 to 28½ bushels; with superphosphate, from 28½ to 31¾; and with the mixed manure, from 30½ to 33¼ bushels. Or, taking the amounts of total produce (grain and straw together), the range of amounts is—without manure, from 4407 to 4976 lb.; with superphosphate, from 4841 to 5658 lb.; and with the mixed manure, from 5808 to 5932 lb. There is, therefore, both in grain and in total produce of the fourth crop of the course, an obvious difference, but certainly less than might have been expected, due to the varying conditions as to manuring in the first year, separated from the fourth by the growth and removal of the intermediate crops.

*Wheat and the consumption of roots on land.*

Next, comparing the effects on the fourth crop—the wheat—of the removal of the first—the turnips—or the retention of them, or of most of their constituents, on the land, it is seen that without manure, under which conditions there were practically no roots grown, the difference of result from removal or otherwise is quite immaterial, and is probably accidental. With superphosphate alone, and more roots grown, the nitrogen of which was doubtless obtained from previous accumulations within the soil, the removal or the retention on the land of the constituents of the turnips should, therefore, more materially affect the condition of the soil for the growth of the succeeding crops. It was shown that the effect was very marked on the barley which immediately succeeded the roots. There was also somewhat less produce, both of clover and of beans, where the roots had been removed; and now, in the case of the fourth crop—the wheat—there is still distinct effect. Thus, taking the fallow portions, there was an average of 30¾ bushels of wheat where the roots had been removed, and 31¾ bushels where they

were fed or retained on the land; the corresponding amounts of total produce being 5348 lb. and 5658 lb. Or, taking the produce on the bean and clover portions, there were 28½ bushels of grain where the roots had been removed, and 31⅝ bushels where they had not been removed, the corresponding amounts of total produce being 4841 lb. and 5307 lb. Lastly, with the mixed manure, including nitrogen, the average produce was, on the fallow portions, 31½ bushels after the removal of the roots, but only 30½ where they had not been removed, the amounts of total produce being, however, 5808 lb. and 5883 lb. On the bean or clover portions, the results were 32⅝ bushels where the roots were carted, and 33¼ bushels where they were not removed; and the amounts of total produce were 5847 and 5932 lb.

Reference to the average produce of the last two courses, the tenth and eleventh, the wheat years of which were of more than average productiveness, shows, in the case of the manured plots, more striking difference in the amount of the fourth crop due to the removal or the retention on the land of the constituents of the first crop—the roots. The roots of those courses were, however, more than average in amount.

The results, both with superphosphate alone and with the mixed manure, afford, therefore, distinct evidence of the effect of the removal or otherwise of the first crop of the course—the turnips—not only on the second and third crops, but on the fourth crop—the wheat—also.

*Effects of leguminous crops and fallow on wheat and other succeeding crops.*

The next point is to illustrate the difference of effect on the other crops of the rotation, on the one hand of the growth and removal of the highly nitrogenous leguminous crop, and on the other of fallowing which removes nothing; and first as to the wheat, which we are now specially considering, and which immediately succeeds the leguminous crop or the fallow.

A careful examination of the average results over the eight courses (second to ninth) will show that, both without manure and with superphosphate alone—that is, under conditions of exhaustion, especially of available nitrogen—the wheat crops were in every case higher after fallow, with its supposed accumulation, than after the leguminous crops, which removed much more nitrogen than the succeeding wheat would require. On the other hand, on the mixed manure plots, where the condition of the land, and especially its nitrogenous condition, was not exhausted, but fairly maintained—there was even rather more average produce of wheat after the removal of the highly nitrogenous leguminous crops than after the accumulations of the fallow.

It is unsafe to form general conclusions from the results of

individual years, since the characters of the seasons may have so much influence. But it may be observed that, after the heavy crops of clover on the superphosphate plots in 1882, and more where the roots were fed than where they had been removed, the wheat crops of the next year, 1883, which were higher than average, were lower after the leguminous crop than after fallow; whilst, on the highly manured plot, they were much the higher after the leguminous crop. In the tenth course, however, after the use of potash as well as superphosphate, there were fair but by no means such heavy crops of clover as in the very favourable season of the preceding course, and there was less where there had then been the larger crop; and in the eleventh course also there was less total produce of beans where the heavier crop of clover had been grown in the ninth course. The result was, that on the average of the last two courses the wheat gave less instead of more total produce after fallow than after the leguminous crops; but more where the roots had been fed than where they had been carted—that is, more where the land was the less exhausted.

The general result is, that where there was not exhaustion, but accumulation due to manure and to increased crop residue, the growth and removal of the leguminous crops not only gave large amounts of nitrogen in the removed crops, whilst the fallow yielded none, but also left more available nitrogen for the succeeding wheat than was rendered available (and remained) from the resources of the soil after the fallow. In other words, not only were the nitrogen and other constituents obtained in the leguminous crops an entire gain compared with the result of fallow, but, on the average of years, a somewhat larger succeeding wheat crop was obtained as well.

Here, then, is a striking illustration of the advantages of the interpolation of leguminous crops instead of fallow with the cereals in our rotations; and it is seen that the benefit may be the greater if the land be not abnormally exhausted, as was the case on the continuously unmanured and on the superphosphate plots.

Although there was thus great difference between the effects, on the one hand, of the growth and removal of a leguminous crop, and on the other of fallow, so far as the third year of the course is concerned; yet, where the manurial conditions were not defective, there was even more wheat succeeding the leguminous crop than succeeding the fallow. The influence of the conditions of the third year of the course does not, however, seem to extend in any marked degree to the crop succeeding the wheat—that is, to the roots com-

mencing the next course, and to the barley succeeding the roots.

So far as the roots are concerned, the average results over the eight courses show, both without manure and with superphosphate alone, that is on the most exhausted plots, that the advantage, if any, is more with the fallow than with the leguminous plots; whilst, with the full manure, there is scarcely any difference of result clearly traceable to the treatment of the land in the third year of the preceding courses. Over the last two courses, again, without manure no benefit accrued to the root-crop by the growth of the leguminous crop as compared with fallow. On the superphosphate plots, however, now with potash, soda, and magnesia, as well, and doubtless more leguminous produce accordingly, there were more roots on the leguminous than on the fallow plots; but, with the full manure, there was practically no difference in the produce of roots on the fallow compared with the leguminous crop plots. Obviously, the fact that there was not materially less produce of roots where the leguminous crops had been grown and removed, as compared with where the land had been fallow, is of itself evidence of the beneficial rather than exhausting effect of their growth and removal, so far as the requirements of the succeeding crops are concerned.

Nor is the effect of the growth and removal of a leguminous crop, compared with fallow, very definite on the barley succeeding the manured roots. It is, however, over the eight courses, in favour of the growth of the leguminous crops; and, though with very small crops, it is, excepting without manure, much more so over the last two courses.

From the results as a whole it may be concluded that, where the land was the most exhausted, the growth of the leguminous crop was correspondingly limited, and, being at the expense of the little accumulation that there was, its removal further exhausted the immediately available supplies; whilst, where the accumulations were greater, the growth was dependent on a more extended root-development, and therefore greater range of collection; the luxuriance was much greater, and the surface-soil at any rate gained by an increased amount of highly nitrogenous leguminous crop-residue. It has further been seen, that the effects of the manuring and treatment of the first crop of the course—the turnips—were manifest in the produce of the fourth crop—the wheat; and also that the effects of fallowing, or of growing and removing a highly nitrogenous crop, in the third year, were clearly traceable on the crop of the fourth year, and to some extent, though in a much less degree, on the subsequent crops commencing the next course.

## THE AMOUNTS OF PRODUCE GROWN IN ROTATION, AND IN THE VARIOUS CROPS GROWN CONTINUOUSLY.

Obviously, when considering what are the benefits arising from rotation as distinguished from the growth of the individual crops continuously, it is desirable, as far as practicable, to compare the results of the two methods in regard to their yield per acre of some of the more important constituents of the crops. For the purposes of such a comparison, it will be of interest to illustrate the point by reference specially to the amounts of *dry matter*, *nitrogen*, *total mineral matter* (*ash*), *phosphoric acid*, and *potash* (and in some cases of lime), in the crops grown in rotation, and in those grown continuously, under as far as possible parallel conditions as to manuring.

*Methods of investigation explained.*

Accordingly, so far as results obtained under rotation are concerned, the amounts of each of the above constituents are calculated in the produce per acre of the respective crops, in each of the eight courses (second to ninth), under each of the twelve different conditions as to manuring, or other treatment; and the average amounts of these per acre per annum are compared with those in the individual crops grown continuously, as a rule in the same seasons as those in which the rotation crops were obtained, and under the same, or nearly parallel, conditions as to manuring.

The amounts of the constituents removed per acre in the rotation crops are calculated from the results of actual analyses; and in the case of the continuously grown crops the amounts of dry matter and ash, and sometimes those of nitrogen, are also calculated from direct determinations; but generally the nitrogen, and always the phosphoric acid, potash, and lime, are calculated from the percentage composition of the rotation crops grown under parallel conditions as to manuring. It may be stated that, for the purposes of the illustrations given, the results of 60 complete analyses of the ashes of representative samples of the rotation crops, and of 8 of the ashes of the bean plant taken at different stages of its growth, have thus contributed; and it may be added, that the ash-analyses were executed by Mr R. Richter, formerly in the Rothamsted Laboratory, but now for some years of Charlottenburg, Berlin.

### *The Amounts of Dry Matter produced in the Rotation, and in the Continuous Crops.*

Table 60 (p. 219) shows the average annual amount of *dry matter* produced per acre, in each of the four crops—roots, barley, leguminous crop, and wheat—grown in rotation, and

TABLE 60.—Experiments on the Rotation of—Roots, Barley, Clover (or Beans), or Fallow, and Wheat; in Agdell Field, Rothamsted. 8 Courses, 32 Years, 1852-1883.

AVERAGE AMOUNTS OF *DRY MATTER* PER ACRE PER ANNUM, GROWN IN ROTATION, COMPARED WITH THOSE IN THE CROPS GROWN CONTINUOUSLY.

| | | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | | Fal-low. | Beans or clover | Fal-low. | Beans or clover | Fal-low. | Beans or clover | Fal-low. | Beans or clover | Fal-low. | Beans or clover | Fal-low. | Beans or clover |
| **SWEDISH TURNIPS.** | | | | | | | | | | | | | |
| | | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Roots | Rotation . . . | 359 | 228 | 323 | 205 | 1724 | 1631 | 1918 | 1901 | 3081 | 3128 | 3107 | 3069 |
| | Continuous[1] . . | 236 | 236 | 236 | 236 | 945 | 945 | 945 | 945 | 1876 | 1876 | 1876 | 1876 |
| | Rotn.+or−cont. | 123 | −8 | 87 | −31 | 779 | 686 | 973 | 956 | 1205 | 1252 | 1231 | 1193 |
| Leaves | Rotation . . . | 56 | 49 | 52 | 45 | 161 | 176 | 179 | 200 | 310 | 355 | 333 | 354 |
| | Continuous[1] . . | 49 | 49 | 49 | 49 | 142 | 142 | 142 | 142 | 345 | 345 | 345 | 345 |
| | Rotn.+or−cont. | 7 | 0 | 3 | −4 | 19 | 34 | 37 | 58 | −35 | 10 | −12 | 9 |
| Total | Rotation . . . | 415 | 277 | 375 | 250[2] | 1885 | 1807 | 2097 | 2101 | 3391 | 3483 | 3440 | 3423 |
| | Continuous[1] . . | 285 | 285 | 285 | 285 | 1087 | 1087 | 1087 | 1087 | 2221 | 2221 | 2221 | 2221 |
| | Rotn.+or−cont. | 130 | −8 | 90 | −35 | 798 | 720 | 1010 | 1014 | 1170 | 1262 | 1219 | 1202 |
| **BARLEY.** | | | | | | | | | | | | | |
| Grain | Rotation . . . | 1396 | 1489 | 1399 | 1307 | 1284 | 1294 | 1665 | 1780 | 1917 | 1987 | 2262 | 2273 |
| | Continuous . . | 875 | 875 | 875 | 875 | 1128 | 1128 | 1128 | 1128 | 2298 | 2298 | 2298 | 2298 |
| | Rotn.+or−cont. | 521 | 614 | 524 | 432 | 156 | 166 | 537 | 652 | −381 | −311 | −36 | −25 |
| Straw | Rotation . . . | 1493 | 1647 | 1486 | 1459 | 1307 | 1355 | 1765 | 1879 | 2029 | 2129 | 2701 | 2613 |
| | Continuous . . | 947 | 947 | 947 | 947 | 1052 | 1052 | 1052 | 1052 | 2489 | 2489 | 2489 | 2489 |
| | Rotn.+or−cont. | 546 | 700 | 539 | 512 | 255 | 303 | 713 | 827 | −460 | −360 | 212 | 124 |
| Total | Rotation . . . | 2889 | 3136 | 2885 | 2766[2] | 2591 | 2649 | 3430 | 3659 | 3946 | 4116 | 4963 | 4886 |
| | Continuous . . | 1822 | 1822 | 1822 | 1822 | 2180 | 2180 | 2180 | 2180 | 4787 | 4787 | 4787 | 4787 |
| | Rotn.+or−cont. | 1067 | 1314 | 1063 | 944 | 411 | 469 | 1250 | 1479 | −841 | −671 | 176 | 99 |
| **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | | | |
| Corn | Rotation . . . | | 631 | | 625 | | 640 | | 769 | | 1147 | | 1292 |
| | Continuous . . | | 234 | | 234 | | 265 | | 265 | | 581 | | 581 |
| | Rotn.+or−cont. | | 397 | | 391 | | 375 | | 504 | | 566 | | 711 |
| Straw | Rotation . . . | | 879 | | 835 | | 978 | | 1213 | | 1457 | | 1540 |
| | Continuous . . | | 422 | | 422 | | 524 | | 524 | | 799 | | 799 |
| | Rotn.+or−cont. | | 457 | | 413 | | 454 | | 689 | | 658 | | 741 |
| Total | Rotation . . . | | 1510 | | 1460 | | 1618 | | 1982 | | 2634 | | 2832 |
| | Continuous . . | | 656 | | 656 | | 789 | | 789 | | 1380 | | 1380 |
| | Rotn.+or−cont. | | 854 | | 804 | | 829 | | 1193 | | 1254 | | 1452 |
| Clover | Rotation . . . | | 2309 | | 1996[2] | | 4717 | | 5645 | | 6714 | | 6838 |
| | Continuous . . | | ? | | ? | | ? | | ? | | ? | | ? |
| Average of 8 courses, beans and clover | | | 1710 | | 1594[2] | | 2393 | | 2807 | | 3654 | | 3832 |
| **WHEAT.** | | | | | | | | | | | | | |
| Grain | Rotation . . . | 1516 | 1368 | 1483 | 1235 | 1636 | 1514 | 1702 | 1668 | 1685 | 1740 | 1599 | 1752 |
| | Continuous . . | 647 | 647 | 647 | 647 | 766 | 766 | 766 | 766 | 1238 | 1238 | 1238 | 1238 |
| | Rotn.+or−cont. | 869 | 721 | 836 | 588 | 870 | 748 | 936 | 902 | 447 | 502 | 361 | 514 |
| Straw | Rotation . . . | 2636 | 2296 | 2573 | 2036 | 2844 | 2513 | 3021 | 2767 | 3158 | 3137 | 3273 | 3186 |
| | Continuous . . | 1082 | 1082 | 1082 | 1082 | 1204 | 1204 | 1204 | 1204 | 2142 | 2142 | 2142 | 2142 |
| | Rotn.+or−cont. | 1554 | 1214 | 1491 | 954 | 1640 | 1309 | 1817 | 1563 | 1016 | 995 | 1131 | 1044 |
| Total | Rotation . . . | 4152 | 3664 | 4056 | 3271[2] | 4480 | 4027 | 4723 | 4435 | 4843 | 4877 | 4872 | 4938 |
| | Continuous . . | 1729 | 1729 | 1729 | 1729 | 1970 | 1970 | 1970 | 1970 | 3380 | 3380 | 3380 | 3380 |
| | Rotn.+or−cont. | 2423 | 1935 | 2327 | 1542 | 2510 | 2057 | 2753 | 2465 | 1463 | 1497 | 1492 | 1558 |

[1] Average per acre, 19 years, 1849-52 and 1856-70.

[2] Probably crop too low owing to a dell.

continuously, as above described. It shows the amounts, separately in the roots, leaves, and total produce, of the turnips; in the grain, straw, and total produce, of the barley, and of the wheat; in the corn, straw, and total produce, of the beans; and in the clover. It will be seen that the arrangement and headings of the columns are exactly the same as in the tables of produce already considered; and that, for each description of crop, or part of the crop, the first line shows the amounts obtained under rotation, the second those in the crop grown continuously, and the third the difference between the two.

*The Dry Matter in the Turnip Crops.*—Referring first to the upper division of the table, relating to the Swedish turnips, it should be stated that results for the crops grown continuously are not available for the same eight years as those grown in rotation; but for each of the three conditions as to manuring, the average for 19 years of growth is taken.

*Manurial treatment.* So far as manuring is concerned, the unmanured and the superphosphate conditions were the same for the rotation and for the continuous crops. But, in the case of the mixed manure, the rotation plots received a larger amount of nitrogen for the roots; in fact, enough to carry the four crops of the course. The continuous plot, on the other hand, received a less amount each year; but, unlike the rotation plots, with no intermediate crops to use up any available residue from the previous application.

*No manure.* The figures show that—without manure—the difference in the amounts of dry matter produced in rotation and in continuous growth are immaterial. The utter failure in both cases without manure is confirmatory of the absolute dependence of this valuable rotation crop on supplies within the soil itself, either from accumulations or from direct manuring.

*With superphosphate.* The less produce of the continuous than of the rotation crops with superphosphate is also quite consistent with the supposition that, under such conditions, the crop greatly exhausts the available nitrogen of the soil, and especially of the surface-soil.

*Mixed manures.* With the mixed mineral and nitrogenous manure, again, there is also considerably less production of dry substance when the crop is grown continuously than when it is grown in rotation. The result is, however, due partly to the larger amount of nitrogen directly supplied by manure to the rotation crops as above referred to, but partly to the fact that when the same description of root-crop, with the same character and range of roots, is grown year after year on the same land, the surface-soil becomes close, and a somewhat impervious pan is formed below; conditions which are very unfavourable for a crop which pre-eminently requires a good

tilth for great development of fibrous root within the soil. The results with the mixed manure are, of course, the most comparable with those of ordinary practice; and it is clear that, however explained, much more produce is obtained under rotation than with continuous growth. It need only further be remarked that, of the total dry matter produced, there are many times as much in the edible root as in the leaf which almost wholly remains only for manure again. *Greater produce in rotation.*

*The Dry Matter in the Barley Crops.*—The second division of Table 60 compares the amounts of dry matter yielded in *barley*, grown, respectively, in rotation, and continuously—that is, year after year on the same land. The results for the continuously grown crops relate to the average produce of the same eight seasons as those in which the rotation crops were obtained. The unmanured and the superphosphate conditions were also quite parallel in the two series of experiments. In the case of the mixed manure results, it should be borne in mind that in the rotation experiments a quantity of manure was applied for the preceding crop—the turnips—which is supposed to carry the whole of the crops of the four years' course; whilst, in the continuous experiments, the quantity of nitrogen, for example, which is applied each year for the immediate crop, amounts to rather more than one-fourth of that applied for four years in the rotation experiments. *Manurial treatment.*

The figures show that—without manure—there was much less dry matter in grain, straw, and total produce, in the crops grown continuously than in those grown in rotation; in fact, in the total produce only about three-fifths as much. The much higher amount under rotation is quite consistent with the explanation that in the rotation experiments without manure, the roots having failed, the barley crop had, in point of fact, the benefit of the preparation which bare fallow is known to confer. *No manure.*

With superphosphate alone, the continuously grown barley crops yielded more dry matter in grain, straw, and in total produce, than those without manure; the excess being largely due to increased capability of utilising the available nitrogen of the surface-soil, under the influence of the phosphatic manure. Both sets of the superphosphate rotation crops yielded more dry matter than the continuous ones, the excess being, however, much less where the rotation roots had been removed than where they had been consumed or spread upon the land. The effect of the growth and accumulation by the previous root-crop, and of the more or less available manurial residue left under the different conditions, as compared with the result when the barley is grown year after year on the same land, is thus very evident. *With superphosphate.* *Crop residue.*

*Mixed manures.*

As already said, the amount of nitrogen annually applied on the mixed manure plot was, for the continuous crops, somewhat more than one-fourth of that applied for the preceding root-crops in the case of the rotation plots. Under these circumstances, the amounts of dry matter in grain, straw, and total produce, were considerably less in the barley grown in rotation where the roots and leaves of the turnips had been removed than in that grown continuously; but where in the case of the rotation barley the root-crops had been consumed or spread upon the land, the average yield of dry matter per acre was much more nearly identical under rotation and under continuous cropping; though upon the whole it was more under rotation. The effects on the second crop of the course, of the manurial and other treatment of the first crop, are here, then, further illustrated. Lastly, it is to be observed that a larger proportion of the total dry matter of the crop is, on the average, accumulated in the straw which is generally retained on the farm, than in the grain which is, as a rule, exported from it.

*Effects of the consumption of roots on the land.*

*Dry matter in grain and straw of barley.*

*Essentials for barley-growing.*

Thus, both the actual and the comparative results clearly show, that the successful growth of the barley was directly dependent on the supplies within the soil, and that the object may be gained, either in a properly manured rotation, or by the direct application of suitable manures, including a liberal supply of nitrogen for the immediate crop. Having regard to the general economy of the farm, the former plan is as a rule the most advantageous; though, owing to the success with which the crop can be grown by direct artificial manures, such manures are often used as supplements; or, sometimes, a barley crop is taken after another cereal, by the aid of artificial manures alone.

*The Dry Matter in the Leguminous Crops.*—The third division of the Table (60) shows the average amounts of dry matter per acre per annum in the corn, straw, and total produce, of the six crops of beans grown in rotation in the eight years; also the average amounts in the same six years when the crop was grown continuously in another field. Below the bean results are given the average amounts per acre per annum in the clover grown in rotation in the remaining two of the eight years; and there are also given the average amounts over the eight years, in the six crops of beans and two of clover. It will be seen, however, that there is no entry in the line for continuous crops of clover, for the simple reason that, as has been shown in various papers, it was found impossible to grow clover year after year on ordinary arable land.

The figures show that, meagre as was the average produce

of dry matter in the crops of beans, even when grown in rotation, they were much less still when grown continuously. This was the case whether we look to the amounts in the corn, the straw, or the total produce. Indeed, the lines of total produce show that the average amounts in the continuously grown crops were, under each condition of manuring or other treatment, less than half as much as those grown in rotation. In both cases, there was somewhat more with superphosphate than without manure, and more still with the mixed manure, including both potash and nitrogen, but even under these conditions, and in rotation, the produce was very small.

*Effects of manures.*

Under each condition as to manuring, the produce of dry matter in the clover grown in rotation was more, and in some very much more, than in the beans so grown. Without manure, it averaged only about 1 ton per acre per annum; with superphosphate, in one case more than 2, and in the other more than 2½ tons; and with the full manure, including potash and nitrogen, it averaged more than 3 tons.

Lastly, the average production of dry substance in the six crops of beans and two of clover taken together was—without manure only about ¾ ton; with superphosphate, in one case little more than 1 ton, and in the other rather more than 1¼ ton; and, with the mixed manure, in both cases less than 1¾ ton. These amounts in the leguminous crops with the mixed manure were, however, greater than those obtained in the turnip crops, but less than those in either the barley or the wheat grown in rotation. The significance of the amounts grown in the leguminous crops will, however, be the more clearly recognised when we come to consider the quantities of nitrogen in the different crops; and also the fact of the large proportion of the manurial constituents of the leguminous crops grown in rotation, that will generally be retained on the farm.

*The Dry Matter in the Wheat Crops.*—The bottom division of the Table (60) shows the average amounts of dry substance in the wheat—grain, straw, and total produce—grown in rotation, and those obtained in the same years in another field under as far as possible parallel conditions as to manuring, but grown continuously—that is, year after year on the same land.

A glance at the figures shows that, both without manure and with superphosphate alone, the amount of dry matter produced was, both in grain and straw, in each case considerably less than half as much in the crops grown continuously as in those grown in rotation; and that, even with the mixed manure, supplying both mineral constituents and nitrogen, it

*Less dry matter in continuous than in rotation crops.*

was considerably less in the continuous than in the rotation crops.

So far as the unmanured and the superphosphate crops are concerned, it is obvious that the growth year after year must be much more exhausting, both of nitrogen and of certain essential mineral constituents, in a condition of composition and of distribution within the soil and subsoil available to one particular crop, than when the crop is grown in alternation with others, of different requirements, habits, and root-ranges.

It has been explained that in the case of the mixed manure rotation plots there was applied for the first crop of the course, besides a full supply of mineral constituents, about 140 lb. of nitrogen; at the average rate, therefore, of 35 lb. per acre per annum over the four years. But, in the case of the continuously grown wheat crops, not only a full supply of mineral manure, but 43 lb. of nitrogen as ammonium-salts, was directly applied every year. The fact of the greater amount of produce on the rotation plots would indicate, therefore, that notwithstanding the growth and removal of the intermediate crops since the application of the manure for the roots, there was more nitrogen, and more of other constituents also, in a condition of composition and of distribution available for the wheat, than in the case of the annual direct supply.

Of course, the proportion of grain and of straw in a wheat crop varies, as it also does in barley, according to variety, soil, season, and other circumstances. It is seen that, in the experimental crops, whether grown in rotation or continuously, there was always much more of the produced dry matter accumulated in the straw than in the grain. Indeed, there was in some cases nearly twice as much. On the assumption, therefore, that as a rule the grain will be sold, and the straw retained on the farm as food and litter, very much more than half of the produced dry matter will be so retained.

*Dry matter in cereals and fallow crops.*

Comparing the amounts of dry matter accumulated in the different rotation crops, and taking as the most normal the quantities obtained under the influence of the mixed manure, including nitrogen, it is seen that, on the average, the two cereal crops—the barley and the wheat—produced approximately equal amounts; and each considerably more than either of the fallow crops—the roots or the Leguminosæ.

## *The Amounts of Nitrogen in the Rotation, and in the Continuous Crops.*

Table 61 (p. 226) shows the average amounts of nitrogen per acre per annum, over the eight years, in the rotation, and in the continuous crops, respectively.

*No manure.* *The Nitrogen in the Root-crops.*—Without manure, with extremely small crops, but very abnormally high percentage of nitrogen in them, the amounts per acre were, in the continuously grown crops only about twice as much as annually comes down as combined nitrogen in the rain and minor aqueous deposits from the atmosphere; whilst, even in the rotation crops, the amounts averaged but little more than in the continuous.

*With superphosphate.* With superphosphate alone, much larger crops, but much lower percentages of nitrogen, there was very much more nitrogen taken up than without manure; in fact, when grown in rotation from three to four times as much, and when grown continuously more than twice as much. There was, too, very much more in the rotation than in the continuous crops. The detailed results published elsewhere, relating to the continuous growth of root-crops afford conclusive evidence that the increased amount of nitrogen taken up by the crop under the influence of phosphatic manures is derived from the resources of the soil itself, by the aid of the greatly enhanced development of fibrous feeding root induced by such manures.

*Mixed manure.* With the mixed manure containing nitrogen there was, as with superphosphate alone, much more nitrogen taken up under rotation than with continuous growth. But, under rotation, there was about twice as much taken up with the mixed manure containing nitrogen as with superphosphate without nitrogen; and with continuous growth there was nearly three times as much taken up as with superphosphate without nitrogen. It is clear, therefore, that the crops, whether grown in rotation or continuously, took up much of the nitrogen supplied by the manure. *Sources of nitrogen for roots.* Indeed, it cannot be doubted that, beyond the small amount of combined nitrogen annually coming down from the atmosphere in rain and the minor aqueous deposits, the source of the large amount of nitrogen of root-crops is the store of it within the soil, whether this be due to accumulations, or to direct supply by manure. *Sources of carbon for roots.* On the other hand, the large amounts of produce obtained by the aid of nitrogenous manures on land to which no carbonaceous manure has been applied for about fifty years is evidence that the atmosphere is at any rate the chief, if not the exclusive, source of the carbon of the crops.

Lastly, as to the results in the table relating to the Swed-

TABLE 61.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 8 courses, 32 years, 1852-1883.

AVERAGE AMOUNTS OF *NITROGEN* PER ACRE PER ANNUM IN THE ROTATION CROPS, COMPARED WITH THOSE IN THE CROPS GROWN CONTINUOUSLY.

| | | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover |
| | | **SWEDISH TURNIPS.** | | | | | | | | | | | |
| | | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Roots | Rotation | 9.4 | 5.8 | 8.5 | 5.3 | 28.7 | 26.8 | 32.9 | 32.2 | 66.3 | 66.7 | 68.2 | 65.5 |
| | Continuous[1] | 6.8 | 6.8 | 6.8 | 6.8 | 13.6 | 13.6 | 13.6 | 13.6 | 40.1 | 40.1 | 40.1 | 40.1 |
| | Rotn. + or − cont. | 2.6 | −1.0 | 1.7 | −1.5 | 15.1 | 13.2 | 19.3 | 18.6 | 26.2 | 26.6 | 28.1 | 25.4 |
| Leaves | Rotation | 2.1 | 1.8 | 1.9 | 1.6 | 6.1 | 6.5 | 6.9 | 7.6 | 12.2 | 13.9 | 13.0 | 13.9 |
| | Continuous[1] | 2.0 | 2.0 | 2.0 | 2.0 | 5.8 | 5.8 | 5.8 | 5.8 | 14.1 | 14.1 | 14.1 | 14.1 |
| | Rotn. + or − cont. | 0.1 | −0.2 | −0.1 | −0.4 | 0.3 | 0.7 | 1.1 | 1.8 | −1.9 | −0.2 | −1.1 | −0.2 |
| Total | Rotation | 11.5 | 7.6 | 10.4 | 6.9[2] | 34.8 | 33.3 | 39.8 | 39.8 | 78.5 | 80.6 | 81.2 | 79.4 |
| | Continuous[1] | 8.8 | 8.8 | 8.8 | 8.8 | 19.4 | 19.4 | 19.4 | 19.4 | 54.2 | 54.2 | 54.2 | 54.2 |
| | Rotn. + or − cont. | 2.7 | −1.2 | 1.6 | −1.9 | 15.4 | 13.9 | 20.4 | 20.4 | 24.3 | 26.4 | 27.0 | 25.2 |
| | | **BARLEY.** | | | | | | | | | | | |
| Grain | Rotation | 21.5 | 23.0 | 21.5 | 20.1 | 17.8 | 17.8 | 22.9 | 24.6 | 29.7 | 30.7 | 35.0 | 34.9 |
| | Continuous | 13.5 | 13.5 | 13.5 | 13.5 | 15.5 | 15.5 | 15.5 | 15.5 | 35.2 | 35.2 | 35.2 | 35.2 |
| | Rotn. + or − cont. | 8.0 | 9.5 | 8.0 | 6.6 | 2.3 | 2.3 | 7.4 | 9.1 | −5.5 | −4.5 | −0.2 | −0.3 |
| Straw | Rotation | 6.6 | 7.4 | 6.6 | 6.6 | 5.5 | 5.7 | 7.5 | 7.9 | 9.5 | 10.0 | 12.5 | 11.9 |
| | Continuous | 4.2 | 4.2 | 4.2 | 4.2 | 4.5 | 4.5 | 4.5 | 4.5 | 11.4 | 11.4 | 11.4 | 11.4 |
| | Rotn. + or − cont. | 2.4 | 3.2 | 2.4 | 2.4 | 1.0 | 1.2 | 3.0 | 3.4 | −1.9 | −1.4 | 1.1 | 0.5 |
| Total | Rotation | 28.1 | 30.4 | 28.1 | 26.7[2] | 23.3 | 23.5 | 30.4 | 32.5 | 39.2 | 40.7 | 47.5 | 46.8 |
| | Continuous | 17.7 | 17.7 | 17.7 | 17.7 | 20.0 | 20.0 | 20.0 | 20.0 | 46.6 | 46.6 | 46.6 | 46.6 |
| | Rotn. + or − cont. | 10.4 | 12.7 | 10.4 | 9.0 | 3.3 | 3.5 | 10.4 | 12.5 | −7.4 | −5.9 | 0.9 | 0.2 |
| | | **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | |
| Corn | Rotation | | 27.5 | | 27.2 | | 30.4 | | 36.6 | | 49.6 | | 55.7 |
| | Continuous | | 9.7 | | 9.7 | | 10.5 | | 10.5 | | 21.4 | | 21.4 |
| | Rotn. + or − cont. | | 17.8 | | 17.5 | | 19.9 | | 26.1 | | 28.2 | | 34.3 |
| Straw | Rotation | | 9.4 | | 8.9 | | 10.1 | | 12.4 | | 14.0 | | 14.5 |
| | Continuous | | 4.6 | | 4.6 | | 5.5 | | 5.5 | | 7.1 | | 7.1 |
| | Rotn. + or − cont. | | 4.8 | | 4.3 | | 4.6 | | 6.9 | | 6.9 | | 7.4 |
| Total | Rotation | | 36.9 | | 36.1 | | 40.5 | | 49.0 | | 63.6 | | 70.2 |
| | Continuous | | 14.3 | | 14.3 | | 16.0 | | 16.0 | | 28.5 | | 28.5 |
| | Rotn. + or − cont. | | 22.6 | | 21.8 | | 24.5 | | 33.0 | | 35.1 | | 41.7 |
| Clover | Rotation | | 55.0 | | 47.0[2] | | 124.5 | | 144.6 | | 167.0 | | 168.4 |
| | Continuous | | ? | | ? | | ? | | ? | | ? | | ? |
| Average of 8 courses, Beans and Clover | | | 41.5 | | 38.9[2] | | 61.5 | | 72.9 | | 89.5 | | 94.7 |
| | | **WHEAT.** | | | | | | | | | | | |
| Grain | Rotation | 26.2 | 23.7 | 25.5 | 21.5 | 27.2 | 25.4 | 28.6 | 28.2 | 28.9 | 30.1 | 27.7 | 30.1 |
| | Continuous | 11.6 | 11.6 | 11.6 | 11.6 | 13.9 | 13.9 | 13.9 | 13.9 | 23.9 | 23.9 | 23.9 | 23.9 |
| | Rotn. + or − cont. | 14.6 | 12.1 | 13.9 | 9.9 | 13.3 | 11.5 | 14.7 | 14.3 | 5.0 | 6.2 | 3.8 | 6.2 |
| Straw | Rotation | 10.4 | 9.1 | 9.9 | 8.2 | 11.8 | 10.5 | 12.3 | 11.7 | 13.2 | 13.6 | 13.8 | 13.1 |
| | Continuous | 5.4 | 5.4 | 5.4 | 5.4 | 5.9 | 5.9 | 5.9 | 5.9 | 10.1 | 10.1 | 10.1 | 10.1 |
| | Rotn. + or − cont. | 5.0 | 3.7 | 4.5 | 2.8 | 5.9 | 4.6 | 6.4 | 5.8 | 3.1 | 3.5 | 3.7 | 3.0 |
| Total | Rotation | 36.6 | 32.8 | 35.4 | 29.7[2] | 39.0 | 35.9 | 40.9 | 39.9 | 42.1 | 43.7 | 41.5 | 43.2 |
| | Continuous | 17.0 | 17.0 | 17.0 | 17.0 | 19.8 | 19.8 | 19.8 | 19.8 | 34.0 | 34.0 | 34.0 | 34.0 |
| | Rotn. + or − cont. | 19.6 | 15.8 | 18.4 | 12.7 | 19.2 | 16.1 | 21.1 | 20.1 | 8.1 | 9.7 | 7.5 | 9.2 |

[1] Calculated on average produce of 19 years, 1849-52 and 1856-70. [2] Probably crop too low owing to a dell.

ish turnips, it is seen that by far the greater part of the nitrogen of the crops was accumulated in the edible root.

*The Nitrogen in the Barley Crops.*—The second division of Table 61 shows the average amounts of nitrogen per acre per annum over the eight years in the rotation and in the continuous barley crops respectively.

Referring to the results chiefly in their bearing on the question of the position of the barley crop in rotation, and of its dependence, or otherwise, on the soil for its supplies of nitrogen, the amounts of it in the total crops, grain and straw together, are of most interest.

*No manure.*

When considering similar results relating to the first crop of the course—the Swedish turnips—it was seen that the average amount of nitrogen per acre per annum in the total crops, roots, and leaves together was only 10 or 11 lb., or even less, when grown without any manure. The results relating to the rotation barley crops show, however, that the average annual removal in them was without manure nearly 30 lb.; the conditions of growth being substantially equivalent to fallow, as practically no root-crop had been removed.

*With superphosphate.*

Consistently with other evidence on the point, the amounts of nitrogen removed in the barley crops grown on the superphosphate plots are seen to be even considerably less than without manure, where the increased crop of roots grown under the influence of the superphosphate had been removed from the land; but where the superphosphate turnips had been fed on the land, the amounts of nitrogen removed in the barley crops are more than under the parallel conditions without manure. In other words, an increased amount of nitrogen having been taken up from the soil by the turnips under the influence of the superphosphate, the land was left poorer in available nitrogen for the barley where the increased turnip crop had been removed from the land, but richer where it, or its manurial residue, was left upon it.

*Mixed manure.*

Again, under the influence of the mixed manure, supplying a liberal amount of nitrogen for the roots, which took up a considerable quantity of it, there was much less nitrogen in the succeeding barley, where the roots so grown had been removed, than where they or their manurial residue had been left on the land.

The actual quantities of nitrogen removed in the barley crops, where the roots had previously been removed, were—without manure nearly 30 lb., with superphosphate about 23½ lb., and with the mixed manure about 40 lb.; but where the roots had been fed or left on the land, they were, without manure about 28 lb., with superphosphate more than 30 lb., and with the mixed manure containing nitrogen about 47 lb.

Comparing the amounts of nitrogen taken up by the rotation with those by the continuously grown barley, it is seen, as might be expected under the conditions described, that both without manure and with superphosphate, the rotation barley took up much more than the continuously grown. Where, however, nitrogenous manure had been applied for the roots, and they had been removed, the succeeding barley took up less nitrogen than the continuous crops which annually received nitrogenous manure; but where the roots had not been removed from the land, the nitrogen was nearly the same in the rotation as in the continuously grown barley —about 47 lb. per acre per annum.

*Effect of the consumption of roots on land.*

The influence of the manuring, and of the amount and treatment of the previous root-crop, on the available supply of nitrogen within the soil for the succeeding barley is, therefore, throughout clearly traceable.

*Nitrogen in grain and straw of barley.*

Lastly, in regard to the nitrogen statistics of the barley crops, it is to be observed that, under whatever conditions of manuring or other treatment, and whether grown in rotation or continuously, there was generally three-fourths or more of the total nitrogen of the crop accumulated in the grain, that is, in the portion which is as a rule sold off the farm; only about one-fourth, therefore, remaining in the straw which is supposed to be retained on the farm.

*The Nitrogen in the Leguminous Crops.*—The third division of the Table (61) gives the results relating to this point.

Referring first to the amounts of nitrogen in the total bean crops (corn and straw together), it is seen that, under each of the three conditions as to manuring, there was from twice to twice and a half as much in the rotation as in the continuously grown beans. The details further show that the advantage was proportionally greater in the corn than in the straw.

*Effects of manures.*

It is next to be observed that the amounts of nitrogen taken up by the rotation beans were—without manure about 36 lb. per acre per annum, and with superphosphate between 40 and 50 lb.; whilst with the mixed manure, containing nitrogen, there were in one case 63.6 lb., and in the other 70.2 lb. In fact, both without manure and with superphosphate, the amounts taken up in the beans were much greater than in either the preceding roots or the preceding barley. With the mixed manure supplying nitrogen, they were also much more than in the preceding barley, but less than in the root-crops, to which the mixed manure had been directly applied.

The point of greatest interest in the results is, however, that under each condition as to manuring, the clover took up

very much more nitrogen than the beans, and very much more than either of the other crops of the rotation under parallel conditions. Thus, even without manure, the average amount of nitrogen in the two crops of clover was—in one case 55 lb. and in the other 47 lb.; with superphosphate it was 124.5 and 144.6 lb.; and with the mixed manure, containing both potash and nitrogen, in the one case 167 lb. and in the other 168.4 lb. Or, taking the average amount of nitrogen in the six bean and two clover crops, there were—without manure 41.5 and 38.9 lb.; with superphosphate 61.5 and 72.9 lb.; and with the mixed manure 89 5 and 94.7 lb. It is, indeed, to the occasional growth of clover that the very large average amounts of nitrogen removed in the leguminous crops of the rotation are to be attributed; and it is these amounts that have to be taken into consideration in comparing the effects on the yield of the other crops of the rotation, and of the rotation as a whole, on the one hand of growing a leguminous crop, and on the other of fallowing, which of course neither yields nor removes nitrogen—unless by loss in drainage. *Quantity of nitrogen assimilated by clover.*

Further, the figures show that there was generally three or even more times as much of the total nitrogen of the bean crops accumulated in the corn as remained in the straw. Lastly, not only does the leguminous crop of the rotation yield the most nitrogen, but, unless in the case of some of the corn of the beans, the whole of it is supposed to be retained on the farm; and there is, in addition, more or less, and sometimes a considerable amount, of nitrogenous crop-residue left within the soil for succeeding crops. *Nitrogenous residue from beans.*

*The Nitrogen in the Wheat Crops.*—The results on this head are recorded in the bottom division of Table 61.

Referring first to the amounts of nitrogen in the total produce (grain and straw together), it is seen that, both without manure and with superphosphate alone, that is with the greatest exhaustion, especially of nitrogen, there was generally about, or even more than, twice as much in the rotation as in the continuous crops. With the full manure, both mineral and nitrogenous, applied for the rotation crops only at the beginning of the course, but for the continuous ones each year for the wheat crop to be grown, the relative deficiency in the continuous crops was, however, very much less. Thus, the figures show that the average amounts of nitrogen in the total wheat crops were — without manure nearly 35 lb. per acre per annum in the rotation crops, and only 17 lb. in the continuous ones; with the superphosphate alone nearly 40 lb. under rotation, but in the continuous crops not 20 lb.; and lastly, with the full manure there was *Effects of different manures.*

an average of more than 42 lb. in the rotation crops, and of 34 lb. in those grown continuously. There is direct evidence, therefore, that there was, under all conditions, more nitrogen available to the crops grown in rotation, than to those growing year after year on the same land; and the advantage is relatively much the greater where no nitrogen had been supplied in manure. The beneficial effect of the interpolation of other crops with the cereals is, therefore, very obvious.

*Advantages of rotation.*

In the case of the second crop of the course—the barley—it was shown that without manure the increased produce in rotation was due to scarcely any roots having been grown, so that the land was practically fallowed for the barley; and now in the case of the fourth crop—the wheat—there was the preparation either of the growth of a leguminous crop leaving a highly nitrogenous residue, or of fallowing. Then with superphosphate alone, the produce of barley, and the yield of nitrogen in it, were less than without manure where the turnips had been removed, but more where they had not, and where, therefore, there was an available nitrogenous residue from the roots; and now in the wheat, the effects on the available supply of nitrogen, on the one hand of the growth and removal of a leguminous crop, and on the other of actual fallow, are observable. Lastly, with the mixed manure the influence of the direct supply of nitrogen for the first crop of the course is obvious. But, as the amounts of nitrogen taken up were not very much more than where none had been supplied, it is evident that in both cases much must have been due to the influence of the preceding leguminous crop or fallow.

*Soil nitrogen increased by leguminous crops.*

Upon the whole, there can be no question that, so far as nitrogen is concerned, the supply within the soil in a condition of combination and of distribution available to the wheat is increased, both by fallow, and by the growth of a leguminous crop, especially of clover; and, further, that such accumulation of available nitrogen by fallow, and of nitrogenous crop-residue by the growth of leguminous crops, is the greater when the soil and subsoil are not abnormally exhausted of organic nitrogen.

*Nitrogen in grain and straw of wheat.*

Lastly, it is to be observed that, under all conditions of manuring, or other treatment, there was, both in the rotation and in the continuous wheat crops, more than twice, and in some cases considerably more than twice, as much of the total nitrogen of the produce stored up in the grain as in the straw. Hence, in the sale of the grain, and the retention of the straw for home use, by far the greater part of the nitrogen of the crop is exported from the farm.

*The Amounts of Total Mineral Matter (Ash) in the Rotation, and in the Continuous Crops.*

The results are given in Table 62 (p. 232) for each of the four descriptions of crop, in exactly the same form as those for the total dry matter and the nitrogen, in Tables 60 and 61 respectively.

The record is deserving of careful study, as showing the very various, and sometimes very large, amounts of mineral or ash-constituents taken up from the soil, and stored up in the different crops, or parts of the crops. But it must suffice here to direct attention to some of the points of chief interest brought to view, on the consideration of the amount, and of the distribution, of some of the more important individual mineral constituents in the respective crops; and for the purposes of such an illustration reference will chiefly be made to the amounts of phosphoric acid, and of potash, but in some cases to that of lime also, in the crops.

*The Amounts of Phosphoric Acid in the Rotation, and in the Continuous Crops.*

Table 63 (p. 233) records the results relating to the amounts of phosphoric acid in the different crops or parts of crops.

*The Phosphoric Acid in the Root-crops.*—The figures show that, without manure, the rotation turnip crops took up an extremely small amount of phosphoric acid, reaching in only one case to an average of 1½ lb. per acre per annum. By superphosphate alone the amount was increased to an average of about 10 lb.; and although this increase only represents about one-tenth of the phosphoric acid applied in manure it is very important, as it is directly connected with the greatly increased development of fibrous feeding root within the soil, which is a special effect of phosphatic manures when applied to turnips; and it is by virtue of this development that these crops so markedly exhaust the available nitrogen within the soil, and especially the surface-soil. As has been shown, there is abundant evidence that the increased amount of nitrogen taken up under the influence of phosphates unaccompanied by any supply of nitrogen itself, is at the expense of the stores of the soil; and that it is not due to a capacity to take up either combined or free nitrogen from the atmosphere, by virtue of an increased development of leaf-surface, under the influence of the phosphatic manure.

*No manure.*

*With superphosphate.*

With the mixed manure, supplying, besides superphosphate, salts of potash, soda, and magnesia, and a liberal

*Mixed manure.*

TABLE 62.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 8 courses, 32 years, 1852-1883.

AVERAGE AMOUNTS OF *MINERAL MATTER (ASH)* PER ACRE PER ANNUM IN THE ROTATION CROPS, COMPARED WITH THOSE IN THE CROPS GROWN CONTINUOUSLY.

| | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover |
| **SWEDISH TURNIPS.** | | | | | | | | | | | | |
| | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Roots: Rotation | 15.7 | 9.5 | 13.8 | 8.8 | 74.1 | 71.3 | 82.5 | 81.9 | 167.8 | 171.2 | 182.4 | 172.3 |
| Roots: Continuous[1] | 10.9 | 10.9 | 10.9 | 10.9 | 40.0 | 40.0 | 40.0 | 40.0 | 100.3 | 100.3 | 100.3 | 100.3 |
| Roots: Rotn. + or − cont. | 4.8 | −1.4 | 2.9 | −2.1 | 34.1 | 31.3 | 42.5 | 41.9 | 67.5 | 70.9 | 82.1 | 72.0 |
| Leaves: Rotation | 6.7 | 6.0 | 6.6 | 5.9 | 17.9 | 20.4 | 19.2 | 22.9 | 35.2 | 41.9 | 40.1 | 41.6 |
| Leaves: Continuous[1] | 5.9 | 5.9 | 5.9 | 5.9 | 16.4 | 16.4 | 16.4 | 16.4 | 40.5 | 40.5 | 40.5 | 40.5 |
| Leaves: Rotn. + or − cont. | 0.8 | 0.1 | 0.7 | 0.0 | 1.5 | 4.0 | 2.8 | 6.5 | −5.3 | 1.4 | −0.4 | 1.1 |
| Total: Rotation | 22.4 | 15.5 | 20.4 | 14.7[2] | 92.0 | 91.7 | 101.7 | 104.8 | 203.0 | 213.1 | 222.5 | 213.9 |
| Total: Continuous[1] | 16.8 | 16.8 | 16.8 | 16.8 | 56.4 | 56.4 | 56.4 | 56.4 | 140.8 | 140.8 | 140.8 | 140.8 |
| Total: Rotn. − or − cont. | 5.6 | −1.3 | 3.6 | −2.1 | 35.6 | 35.3 | 45.3 | 48.4 | 62.2 | 72.3 | 81.7 | 73.1 |
| **BARLEY.** | | | | | | | | | | | | |
| Grain: Rotation | 34.8 | 35.9 | 34.2 | 30.7 | 34.9 | 33.8 | 44.1 | 45.9 | 50.7 | 51.5 | 58.1 | 57.7 |
| Grain: Continuous | 21.5 | 21.5 | 21.5 | 21.5 | 28.4 | 28.4 | 28.4 | 28.4 | 58.8 | 58.8 | 58.8 | 58.8 |
| Grain: Rotn. + or − cont. | 13.3 | 14.4 | 12.7 | 9.2 | 6.5 | 5.4 | 15.7 | 17.5 | −8.1 | −7.3 | −0.7 | −1.1 |
| Straw: Rotation | 81.3 | 87.5 | 79.2 | 76.1 | 75.6 | 77.7 | 96.9 | 99.8 | 113.5 | 116.8 | 145.6 | 144.9 |
| Straw: Continuous | 47.3 | 47.3 | 47.3 | 47.3 | 55.6 | 55.6 | 55.6 | 55.6 | 130.6 | 130.6 | 130.6 | 130.6 |
| Straw: Rotn. + or − cont. | 34.0 | 40.2 | 31.9 | 28.8 | 20.0 | 22.1 | 41.3 | 44.2 | −17.1 | −13.8 | 15.0 | 14.3 |
| Total: Rotation | 116.1 | 123.4 | 113.4 | 106.8[2] | 110.5 | 111.5 | 141.0 | 145.7 | 164.2 | 168.3 | 203.7 | 202.6 |
| Total: Continuous | 68.8 | 68.8 | 68.8 | 68.8 | 84.0 | 84.0 | 84.0 | 84.0 | 189.4 | 189.4 | 189.4 | 189.4 |
| Total: Rotn. + or − cont. | 47.3 | 54.6 | 44.6 | 38.0 | 26.5 | 27.5 | 57.0 | 61.7 | −25.2 | −21.1 | 14.3 | 13.2 |
| **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | | |
| Corn: Rotation | | 18.5 | | 18.4 | | 20.2 | | 24.1 | | 35.8 | | 40.7 |
| Corn: Continuous | | 7.6 | | 7.6 | | 9.4 | | 9.4 | | 21.1 | | 21.1 |
| Corn: Rotn. + or − cont. | | 10.9 | | 10.8 | | 10.8 | | 14.7 | | 14.7 | | 19.6 |
| Straw: Rotation | | 53.1 | | 53.3 | | 65.8 | | 72.5 | | 87.7 | | 90.8 |
| Straw: Continuous | | 28.5 | | 28.5 | | 35.1 | | 35.1 | | 54.2 | | 54.2 |
| Straw: Rotn. + or − cont. | | 24.6 | | 24.8 | | 30.7 | | 37.4 | | 33.5 | | 36.6 |
| Total: Rotation | | 71.6 | | 71.7 | | 86.0 | | 96.6 | | 123.5 | | 131.5 |
| Total: Continuous | | 36.1 | | 36.1 | | 44.5 | | 44.5 | | 75.3 | | 75.3 |
| Total: Rotn. + or − cont. | | 35.5 | | 35.6 | | 41.5 | | 52.1 | | 48.2 | | 56.2 |
| Clover: Rotation | | 198.3 | | 172.6[2] | | 421.3 | | 487.5 | | 509.8 | | 612.5 |
| Clover: Continuous | | ? | | ? | | ? | | ? | | ? | | ? |
| Average of 8 courses, Beans and Clover | | 103.3 | | 96.9[2] | | 169.8 | | 194.8 | | 235.1 | | 251.7 |
| **WHEAT.** | | | | | | | | | | | | |
| Grain: Rotation | 26.3 | 24.6 | 25.6 | 22.1 | 29.6 | 29.1 | 30.0 | 31.1 | 30.6 | 33.3 | 29.5 | 33.2 |
| Grain: Continuous | 13.6 | 13.6 | 13.6 | 13.6 | 16.3 | 16.3 | 16.3 | 16.3 | 25.0 | 25.0 | 25.0 | 25.0 |
| Grain: Rotn. − or − cont. | 12.7 | 11.0 | 12.0 | 8.5 | 13.3 | 12.8 | 13.7 | 14.8 | 5.6 | 8.3 | 4.5 | 8.2 |
| Straw: Rotation | 167.9 | 157.9 | 160.9 | 143.5 | 181.4 | 172.4 | 182.5 | 182.0 | 187.9 | 198.9 | 190.7 | 196.7 |
| Straw: Continuous | 74.4 | 74.4 | 74.4 | 74.4 | 89.3 | 89.3 | 89.3 | 89.3 | 136.7 | 136.7 | 136.7 | 136.7 |
| Straw: Rotn. + or − cont. | 93.5 | 83.5 | 86.5 | 69.1 | 92.1 | 83.1 | 93.2 | 92.7 | 51.2 | 62.2 | 54.0 | 60.0 |
| Total: Rotation | 194.2 | 182.5 | 186.5 | 165.6[2] | 211.0 | 201.5 | 212.5 | 213.1 | 218.5 | 232.2 | 220.2 | 229.9 |
| Total: Continuous | 88.0 | 88.0 | 88.0 | 88.0 | 105.6 | 105.6 | 105.6 | 105.6 | 161.7 | 161.7 | 161.7 | 161.7 |
| Total: Rotn. + or − cont. | 106.2 | 94.5 | 98.5 | 77.6 | 105.4 | 95.9 | 106.9 | 107.5 | 56.8 | 70.5 | 58.5 | 68.2 |

[1] Average per acre, 19 years, 1849-52 and 1856-70.

[2] Probably crop too low owing to a dell.

TABLE 63.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 8 courses, 32 years, 1852-1883.

AVERAGE AMOUNTS OF *PHOSPHORIC ACID* PER ACRE PER ANNUM IN THE ROTATION CROPS, COMPARED WITH THOSE IN THE CROPS GROWN CONTINUOUSLY.

| | | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover |
| **SWEDISH TURNIPS.** | | | | | | | | | | | | | |
| | | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Roots | Rotation | 1.26 | 0.77 | 1.11 | 0.71 | 7.91 | 7.68 | 8.83 | 8.78 | 16.07 | 17.02 | 18.14 | 17.12 |
| | Continuous [1] | 0.88 | 0.88 | 0.88 | 0.88 | 4.14 | 4.14 | 4.14 | 4.14 | 9.91 | 9.91 | 9.91 | 9.91 |
| | Rotn. + or − cont. | 0.38 | −0.11 | 0.23 | −0.17 | 3.77 | 3.54 | 4.69 | 4.64 | 6.76 | 7.11 | 8.23 | 7.21 |
| Leaves | Rotation | 0.29 | 0.25 | 0.28 | 0.25 | 1.27 | 1.44 | 1.36 | 1.62 | 2.79 | 3.17 | 3.04 | 3.10 |
| | Continuous [1] | 0.25 | 0.25 | 0.25 | 0.25 | 1.16 | 1.16 | 1.16 | 1.16 | 3.07 | 3.07 | 3.07 | 3.07 |
| | Rotn. + or − cont. | 0.04 | 0.00 | 0.03 | 0.00 | 0.11 | 0.28 | 0.20 | 0.46 | −0.28 | 0.10 | −0.03 | 0.00 |
| Total | Rotation | 1.55 | 1.02 | 1.39 | 0.96[2] | 9.18 | 9.12 | 10.19 | 10.40 | 19.46 | 20.19 | 21.18 | 20.28 |
| | Continuous [1] | 1.13 | 1.13 | 1.13 | 1.13 | 5.30 | 5.30 | 5.30 | 5.30 | 12.98 | 12.98 | 12.98 | 12.98 |
| | Rotn. + or − cont. | 0.42 | −0.11 | 0.26 | −0.17 | 3.88 | 3.82 | 4.89 | 5.10 | 6.48 | 7.21 | 8.20 | 7.30 |
| **BARLEY.** | | | | | | | | | | | | | |
| Grain | Rotation | 11.24 | 11.59 | 11.02 | 9.89 | 12.29 | 11.91 | 15.52 | 16.16 | 18.34 | 18.63 | 21.04 | 20.90 |
| | Continuous | 6.95 | 6.95 | 6.95 | 6.95 | 10.00 | 10.00 | 10.00 | 10.00 | 21.31 | 21.31 | 21.31 | 21.31 |
| | Rotn. + or − cont. | 4.29 | 4.64 | 4.07 | 2.94 | 2.29 | 1.91 | 5.52 | 6.16 | −2.97 | −2.68 | −0.27 | −0.41 |
| Straw | Rotation | 1.87 | 2.03 | 1.82 | 1.74 | 1.80 | 1.85 | 2.32 | 2.38 | 2.87 | 2.96 | 3.68 | 3.53 |
| | Continuous | 1.10 | 1.10 | 1.10 | 1.10 | 1.33 | 1.33 | 1.33 | 1.33 | 3.30 | 3.30 | 3.30 | 3.30 |
| | Rotn. + or − cont. | 0.77 | 0.93 | 0.72 | 0.64 | 0.47 | 0.52 | 0.99 | 1.05 | −0.43 | −0.34 | 0.38 | 0.23 |
| Total | Rotation | 13.11 | 13.62 | 12.84 | 11.63[2] | 14.09 | 13.76 | 17.84 | 18.54 | 21.21 | 21.59 | 24.72 | 24.43 |
| | Continuous | 8.05 | 8.05 | 8.05 | 8.05 | 11.33 | 11.33 | 11.33 | 11.33 | 24.61 | 24.61 | 24.61 | 24.61 |
| | Rotn. + or − cont. | 5.06 | 5.57 | 4.79 | 3.58 | 2.76 | 2.43 | 6.51 | 7.21 | −3.40 | −3.02 | 0.11 | −0.18 |
| **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | | | |
| Corn | Rotation | | 5.15 | | 5.14 | | 6.81 | | 8.18 | | 11.49 | | 13.05 |
| | Continuous | | 2.11 | | 2.11 | | 3.16 | | 3.16 | | 6.75 | | 6.75 |
| | Rotn. + or − cont. | | 3.04 | | 3.03 | | 3.65 | | 5.02 | | 4.74 | | 6.30 |
| Straw | Rotation | | 1.17 | | 1.17 | | 1.78 | | 1.97 | | 1.99 | | 2.06 |
| | Continuous | | 0.63 | | 0.63 | | 0.95 | | 0.95 | | 1.24 | | 1.24 |
| | Rotn. + or − cont. | | 0.54 | | 0.54 | | 0.83 | | 1.02 | | 0.75 | | 0.82 |
| Total | Rotation | | 6.32 | | 6.31 | | 8.59 | | 10.15 | | 13.48 | | 15.11 |
| | Continuous | | 2.74 | | 2.74 | | 4.11 | | 4.11 | | 7.99 | | 7.99 |
| | Rotn. + or − cont. | | 3.58 | | 3.57 | | 4.48 | | 6.04 | | 5.49 | | 7.12 |
| Clover | Rotation | | 8.04 | | 6.96[2] | | 20.30 | | 22.69 | | 31.09 | | 34.29 |
| | Continuous | | ? | | ? | | ? | | ? | | ? | | ? |
| Average of 8 courses, beans and clover | | | 6.75 | | 6.48[2] | | 11.52 | | 13.36 | | 18.03 | | 19.90 |
| **WHEAT.** | | | | | | | | | | | | | |
| Grain | Rotation | 12.53 | 11.18 | 12.19 | 10.50 | 14.48 | 14.23 | 14.68 | 15.25 | 15.12 | 16.50 | 14.58 | 16.43 |
| | Continuous | 6.45 | 6.45 | 6.45 | 6.45 | 7.99 | 7.99 | 7.99 | 7.99 | 12.40 | 12.40 | 12.40 | 12.40 |
| | Rotn. + or − cont. | 6.08 | 4.73 | 5.74 | 4.05 | 6.49 | 6.24 | 6.69 | 7.26 | 2.72 | 4.10 | 2.18 | 4.03 |
| Straw | Rotation | 2.87 | 2.73 | 2.76 | 2.48 | 3.87 | 3.75 | 3.84 | 3.95 | 4.94 | 5.46 | 5.00 | 5.31 |
| | Continuous | 1.27 | 1.27 | 1.27 | 1.27 | 1.88 | 1.88 | 1.88 | 1.88 | 3.62 | 3.62 | 3.62 | 3.62 |
| | Rotn. + or − cont. | 1.60 | 1.46 | 1.49 | 1.21 | 1.99 | 1.87 | 1.96 | 2.07 | 1.32 | 1.84 | 1.38 | 1.69 |
| Total | Rotation | 15.40 | 13.91 | 14.95 | 12.98[2] | 18.35 | 17.98 | 18.52 | 19.20 | 20.06 | 21.96 | 19.58 | 21.74 |
| | Continuous | 7.72 | 7.72 | 7.72 | 7.72 | 9.87 | 9.87 | 9.87 | 9.87 | 16.02 | 16.02 | 16.02 | 16.02 |
| | Rotn. + or − cont. | 7.68 | 6.19 | 7.23 | 5.26 | 8.48 | 8.11 | 8.65 | 9.33 | 4.04 | 5.94 | 3.56 | 5.72 |

[1] Calculated on average produce of 19 years, 1849-52 and 1856-70. [2] Probably crop too low owing to a dell.

amount of nitrogen as well, there was, although the supply of phosphoric acid by manure was exactly the same, now about twice as much of it taken up, as a coincident of the greatly increased growth, due partly to the other mineral constituents at the same time added, but especially to the influence of the increased available supply of nitrogen. Still, only a small proportion of the phosphoric acid applied was taken up, considering the recognised importance of its application for turnips, and its undoubted specific effects on their growth as above described.

*Rotation and continuous crops.* Comparing the amounts of phosphoric acid in the rotation crops with those in the continuous ones, the equally small, or even smaller, amount taken up without manure by the latter, is further confirmation of the incapability of this assumed restorative crop to yield any practical amount of produce without adequate soil supplies. With superphosphate alone, as also with the mixed manure, the continuous crops took up little more than half as much phosphoric acid as the rotation ones under the assumed fairly parallel conditions as to manuring. The deficiency is, however, obviously not due to any deficiency of supply within the soil, but is only a coincident of the less total growth, attributable to a great extent, as has been explained, to the unfavourable mechanical condition of the soil induced by the continuous growth of the crop. *Unfavourable mechanical condition of soil.*

*Phosphoric acid in edible root.* Lastly, in regard to the phosphoric acid in the turnip crops, it is to be observed that in all cases much more was accumulated in the edible roots than in the leaves which remain only for manure again; indeed, in the case of the most normal crops, those grown in rotation with the full mixed manure, there was five or six times as much accumulated in the roots as in the leaves.

*The Phosphoric Acid in the Barley Crops.*—Looking first to the amounts in the total produce, grain and straw together, and to the portions of the rotation plots from which the previous root-crops had been removed, it is seen that, without manure, rather more than 13 lb. of phosphoric acid was, on the average, annually removed in the barley crops; and where superphosphate had previously been applied for the roots, the succeeding barley took up only about 14 lb., that is scarcely any more than without the supply of it; but where the mixed manure, including nitrogen, had been applied for the roots, there was about one-and-a-half time as much, or rather over 21 lb. of phosphoric acid in the succeeding barley crops. Then, where the root-crops had not been removed from the land, the amounts of phosphoric acid in the succeeding barley crops were, without manure, about 12 lb. per

*No manure.*

*With superphosphate.*

*Mixed manure.*

*Removal of root-crops.*

acre, with superphosphate about 18 lb., and with the mixed manure nearly 25 lb. In the case of the phosphoric acid, therefore, as in that of the nitrogen, the influence of the manuring, and other treatment, of the preceding crop of the course, is clearly reflected in the amounts taken up in the succeeding barley.

*Rotation and continuous crops.*

Comparing the amounts of phosphoric acid in the rotation barley crops with those in the continuously grown ones, it is seen that, both without manure and with superphosphate, the rotation crops took up considerably the most phosphoric acid; and this was the case notwithstanding that the continuously grown crops were annually manured with superphosphate, whilst for those grown in rotation the application had only been for the preceding crop—the turnips. The less assimilation in the case of the continuous crops was doubtless due to the diminished total growth, which in its turn was due to the greater exhaustion of the available nitrogen of the soil with the annual growth. Consistently with this view, where the mixed manure supplying an abundance of nitrogen was applied, and the crops, both rotation and continuous, were pretty full averages for the particular soil and the seasons of growth, the amounts of phosphoric acid in the rotation crops where the roots had not been removed were almost identical with those in the continuous crops. Where, however, the rotation roots had been removed, carrying off therefore the whole of the nitrogen that had been taken up, the succeeding barley crops were accordingly not full for the seasons of their growth, and the amounts of phosphoric acid in them were less than in the continuously grown crops.

*Phosphoric acid in grain and straw of barley.*

The figures relating to both the rotation and the continuous barley further show, that about six-sevenths of the total phosphoric acid of the crops is accumulated in the grain which is supposed to be sold off the farm. There was, indeed, even a somewhat higher proportion where phosphoric acid was supplied in the manure. Lastly, as in the cases of the total produce, the dry matter, and the nitrogen, there is much less difference between the amounts of phosphoric acid taken up under the three different conditions as to manuring than in the case of the turnips. That is, the assumed restorative crop is much more dependent on direct manuring to yield any crop at all than is the cereal crop, which is assumed to be benefited by the interpolation of it.

*Dependence of roots on manure.*

*Effects of manures.*

*The Phosphoric Acid in the Leguminous Crops.*—Referring to the third division of Table 63, it is seen that the amounts of phosphoric acid in the total produce of beans (corn and straw together) were more where superphosphate was supplied than without manure, and more still under the influence of the

*Rotation and continuous crops.* mixed manure, containing, besides superphosphate, salts of potash, soda, and magnesia, and nitrogen also. But, under all three conditions as to manuring, the continuously grown crops take up much less than those grown in rotation. Whether, however, grown in rotation or continuously, three, four, or more times as much of the phosphoric acid is finally accumulated in the corn as remains in the straw. In reference to all the results with beans, however, it is to be borne in mind that under none of the conditions were good crops obtained.

*Clover.* The clover took up, without manure, little more phosphoric acid than the rotation beans; but, with superphosphate, the clover took up more than twice as much as the beans; and with the mixed manure it took up more still, and also more than twice as much as the beans grown under the same conditions.

*Beans.* Taking the average of the six crops of beans and two crops of clover grown in the eight courses, there was, both without manure and with superphosphate, much less phosphoric acid taken up than in either the preceding barley or the succeeding wheat; and even with the mixed manure, which gave the most normal crops, the average amount of phosphoric acid taken up in the beans and clover was less than in either of the two cereals under the same conditions.

*Effects of manures.* *The Phosphoric Acid in the Wheat Crops.*—The bottom division of Table 63 shows that the rotation wheat, as did the rotation barley, took up very much more phosphoric acid without manure than did either of the so-called fallow crops—the turnips or the leguminous crops. With superphosphate, again, both the wheat and barley took up more than either the turnips or the average of the leguminous crops. With the full mixed manure, however, when each of the four descriptions of crop grew more normally, the amount of phosphoric acid taken up was more nearly uniform in the four cases; the barley, however, then yielding more than the wheat, more than the turnips, more than the average of the leguminous crops, but all considerably less than the average of the two years of clover.

*Rotation and continuous crops.* Comparing the amounts of phosphoric acid in the total produce of the rotation with those in the continuously grown wheat, it is seen that there is, without manure, only about half as much taken up in the continuous as in the rotation crops; with superphosphate, again, only about half as much in the continuous as in the rotation; but with the more normal growth, when the full mixed manure was annually applied to the continuously grown crops, there was, with the fuller produce, proportionally much more phosphoric acid taken up

—indeed, on the average, about three-fourths as much in the continuous as in the rotation crops.

Lastly, the figures show that by far the larger proportion of the total phosphoric acid in the wheat crops is stored up in the grain, which is assumed to be sold off the farm. Thus, without manure more than four-fifths, and with superphospate nearly four-fifths, of the total phosphoric acid of the crops was in the grain. With the mixed manure, however, with rather larger total amounts taken up than with superphosphate alone, there was comparatively little more stored up in the grain, the excess for the most part remaining in the straw. The larger amount of total phosphoric acid taken up with the mixed manure than with superphosphate, the amount supplied by manure being the same in the two cases, is to be attributed to the coincident supply of other constituents in the mixed manure, inducing greater luxuriance, and with it greater activity of collection. *Phosphoric acid in grain and straw of wheat.*

### *The Amounts of Potash in the Rotation, and in the Continuous Crops.*

The results relating to the amount and distribution of potash in the rotation and in the continuous crops are recorded in Table 64 (p. 239).

*The Potash in the Root-crops.*—Before referring to the details on this point, attention should be recalled to the facts fully illustrated in other papers—that root-crops are essentially sugar crops; that the very characteristic effect which nitrogenous manures exert on their increased growth is mainly represented by a greatly increased production of the non-nitrogenous substance—sugar; that, however the action is to be explained, it is certain that the presence of potash is an important condition of the formation in plants of carbohydrates generally; and that, in the case of root-crops, the production of the carbohydrate—sugar—is greatly dependent on a liberal available supply of potash. *Sugar in root-crops.*

Referring to the upper division of the table, and for the purpose of the first illustrations to the rotation results, it is seen that, without manure and very abnormally small crops, there were only three, four, or five times as much potash in the roots as in the leaves; with superphosphate, on the other hand, and greatly increased root development, there were eight or nine times as much potash in the roots as in the leaves; and with the mixed manure (including potash), there were, with the further greatly increased actual amount of roots and of potash in them, seven or eight times as much in the roots as in the leaves. That is, there was the greatest *Potash in roots and leaves of turnips.*

accumulation of potash with the greatest accumulation of sugar.

*Effects of manures.* Looking to the actual amounts of potash in the total produce, roots and leaves together, of the rotation crops, it is seen that, without manure, there was only from 4 to 6 lb. of potash per acre per annum; but with superphosphate, without potash supply, from 25 to 28 lb. That is, without any supply by manure the plants were able to gather about 20 lb. more potash per acre per annum from the soil itself, by virtue of the greatly increased development of fibrous feeding root under the influence of the phosphatic manure. With the mixed manure, however, containing potash, there was about three times as much of it taken up as with superphoshate alone. But, with the supply of potash there was also a liberal supply of available nitrogen, to which the greatly increased growth is largely to be attributed; and with the increased luxuriance much more potash was of course required if there were to be a correspondingly increased formation of the characteristic non-nitrogenous product of the cultivated root-sugar. Thus, we have—without manure only 4 to 6 lb. of potash taken up, with superphosphate (without potash) from 25 to 28 lb., and with the mixed manure, supplying besides phosphoric acid both nitrogen and potash, nearly 80 lb. of potash per acre per annum in the crops.

*Rotation and continuous crops.* Comparing the amounts of potash in the rotation crops with those in the continuously grown ones, it is seen that—without manure, and practically no growth, there was but little difference in the amounts taken up; with superphosphate there was little more than half as much taken up in the continuous as in the rotation crops; whilst with the mixed manure, with full supply of potash, and much larger amounts of it in both the rotation and continuous crops, there was rather less than two-thirds as much in the continuous as in the rotation crops. The deficient amounts in the continuous crops are, however, as in the case of the other constituents, coincidents of the less amounts of produce of the continuous crops; which, as has been pointed out, were, in the case of the superphosphate plot, due partly to the greater exhaustion of available nitrogen of the surface soil with the continuous growth, but partly also to the unfavourable mechanical condition of the soil induced by such growth; and this was probably the chief cause of the deficient produce in the case of the mixed manure crops also.

*Unfavourable mechanical condition of soil.*

*The Potash in the Barley Crops.*—The second division of Table 64 records the results on this point.

In the case of the turnips it was found that much more potash was accumulated in the roots than in the leaves; and

TABLE 64.—EXPERIMENTS ON THE ROTATION OF—ROOTS, BARLEY, CLOVER (OR BEANS), OR FALLOW, AND WHEAT; IN AGDELL FIELD, ROTHAMSTED. 8 courses, 32 years, 1852-1883.

AVERAGE AMOUNTS OF *POTASH* PER ACRE PER ANNUM IN THE ROTATION CROPS, COMPARED WITH THOSE IN THE CROPS GROWN CONTINUOUSLY.

| | | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover |
| **SWEDISH TURNIPS.** | | | | | | | | | | | | | |
| | | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| Roots | Rotation | 5.00 | 3.04 | 4.40 | 2.82 | 22.49 | 21.67 | 25.05 | 24.86 | 66.62 | 67.99 | 72.48 | 68.53 |
| | Continuous [1] | 3.48 | 3.48 | 3.48 | 3.48 | 12.08 | 12.08 | 12.08 | 12.08 | 39.51 | 39.51 | 39.51 | 39.51 |
| | Rotn. + or − cont. | 1.52 | −0.44 | 0.92 | −0.66 | 10.41 | 9.59 | 12.97 | 12.78 | 27.11 | 28.48 | 32.97 | 29.02 |
| Leaves | Rotation | 1.07 | 0.95 | 1.04 | 0.93 | 2.60 | 2.96 | 2.77 | 3.31 | 8.66 | 10.32 | 9.89 | 10.25 |
| | Continuous [1] | 0.94 | 0.94 | 0.94 | 0.94 | 2.38 | 2.38 | 2.38 | 2.38 | 9.98 | 9.98 | 9.98 | 9.98 |
| | Rotn. + or − cont. | 0.13 | 0.01 | 0.10 | −0.01 | 0.22 | 0.58 | 0.39 | 0.93 | −1.32 | 0.34 | −0.09 | 0.27 |
| Total | Rotation | 6.07 | 3.99 | 5.44 | 3.75[2] | 25.09 | 24.63 | 27.52 | 28.17 | 75.28 | 78.31 | 82.37 | 78.78 |
| | Continuous [1] | 4.42 | 4.42 | 4.42 | 4.42 | 14.46 | 14.46 | 14.46 | 14.46 | 49.49 | 49.49 | 49.49 | 49.49 |
| | Rotn. + or − cont. | 1.65 | −0.43 | 1.02 | −0.67 | 10.63 | 10.17 | 13.86 | 13.71 | 25.79 | 28.82 | 32.88 | 29.29 |
| **BARLEY.** | | | | | | | | | | | | | |
| Grain | Rotation | 8.13 | 8.38 | 7.97 | 7.15 | 8.09 | 7.85 | 10.23 | 10.65 | 12.33 | 12.52 | 14.14 | 14.04 |
| | Continuous | 5.03 | 5.03 | 5.03 | 5.03 | 6.59 | 6.59 | 6.59 | 6.59 | 14.32 | 14.32 | 14.32 | 14.32 |
| | Rotn. + or − cont. | 3.10 | 3.35 | 2.94 | 2.12 | 1.50 | 1.26 | 3.64 | 4.06 | −1.99 | −1.80 | −0.18 | −0.28 |
| Straw | Rotation | 10.83 | 11.81 | 10.52 | 10.09 | 9.32 | 9.50 | 12.10 | 12.54 | 18.41 | 18.97 | 23.48 | 23.31 |
| | Continuous | 6.45 | 6.45 | 6.45 | 6.45 | 7.03 | 7.03 | 7.03 | 7.03 | 21.00 | 21.00 | 21.00 | 21.00 |
| | Rotn. + or − cont. | 4.38 | 5.36 | 4.07 | 3.64 | 2.29 | 2.47 | 5.07 | 5.51 | −2.59 | −2.03 | 2.48 | 2.31 |
| Total | Rotation | 18.96 | 20.19 | 18.49 | 17.24[2] | 17.41 | 17.35 | 22.33 | 23.19 | 30.74 | 31.49 | 37.62 | 37.35 |
| | Continuous | 11.48 | 11.48 | 11.48 | 11.48 | 13.62 | 13.62 | 13.62 | 13.62 | 35.32 | 35.32 | 35.32 | 35.32 |
| | Rotn. + or − cont. | 7.48 | 8.71 | 7.01 | 5.76 | 3.79 | 3.73 | 8.71 | 9.57 | −4.58 | −3.83 | 2.30 | 2.03 |
| **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | | | |
| Corn | Rotation | | 7.26 | | 7.23 | | 7.35 | | 8.79 | | 15.20 | | 17.25 |
| | Continuous | | 2.98 | | 2.98 | | 3.46 | | 3.46 | | 8.94 | | 8.94 |
| | Rotn. + or − cont. | | 4.28 | | 4.25 | | 3.89 | | 5.33 | | 6.26 | | 8.31 |
| Straw | Rotation | | 2.87 | | 2.87 | | 3.47 | | 4.01 | | 6.96 | | 7.21 |
| | Continuous | | 1.54 | | 1.54 | | 1.82 | | 1.82 | | 4.33 | | 4.33 |
| | Rotn. + or − cont. | | 1.33 | | 1.33 | | 1.65 | | 2.19 | | 2.63 | | 2.88 |
| Total | Rotation | | 10.13 | | 10.10 | | 10.82 | | 12.80 | | 22.16 | | 24.46 |
| | Continuous | | 4.52 | | 4.52 | | 5.28 | | 5.28 | | 13.27 | | 13.27 |
| | Rotn. + or − cont. | | 5.61 | | 5.58 | | 5.54 | | 7.52 | | 8.89 | | 11.19 |
| Clover | Rotation | | 34.18 | | 29.67[2] | | 57.63 | | 65.48 | | 123.12 | | 132.62 |
| | Continuous | | ? | | ? | | ? | | ? | | ? | | ? |
| Average of 8 courses, beans and clover | | | 16.14 | | 14.99[2] | | 22.52 | | 25.96 | | 47.40 | | 51.50 |
| **WHEAT.** | | | | | | | | | | | | | |
| Grain | Rotation | 8.65 | 8.08 | 8.42 | 7.26 | 9.55 | 9.39 | 9.69 | 10.06 | 9.90 | 10.82 | 9.55 | 10.78 |
| | Continuous | 4.45 | 4.45 | 4.45 | 4.45 | 5.27 | 5.27 | 5.27 | 5.27 | 8.12 | 8.12 | 8.12 | 8.12 |
| | Rotn. + or − cont. | 4.20 | 3.63 | 3.97 | 2.81 | 4.28 | 4.12 | 4.42 | 4.79 | 1.78 | 2.70 | 1.43 | 2.66 |
| Straw | Rotation | 19.12 | 17.94 | 18.30 | 16.31 | 20.25 | 19.14 | 20.45 | 20.21 | 25.85 | 27.47 | 26.21 | 27.12 |
| | Continuous | 8.49 | 8.49 | 8.49 | 8.49 | 10.00 | 10.00 | 10.00 | 10.00 | 18.81 | 18.81 | 18.81 | 18.81 |
| | Rotn. + or − cont. | 10.63 | 9.45 | 9.81 | 7.82 | 10.25 | 9.14 | 10.45 | 10.21 | 7.04 | 8.66 | 7.40 | 8.31 |
| Total | Rotation | 27.77 | 26.02 | 26.72 | 23.57[2] | 29.80 | 28.53 | 30.14 | 30.27 | 35.75 | 38.29 | 35.76 | 37.90 |
| | Continuous | 12.94 | 12.94 | 12.94 | 12.94 | 15.27 | 15.27 | 15.27 | 15.27 | 26.93 | 26.93 | 26.93 | 26.93 |
| | Rotn. + or − cont. | 14.83 | 13.08 | 13.78 | 10.63 | 14.53 | 13.26 | 14.87 | 15.00 | 8.82 | 11.36 | 8.83 | 10.97 |

[1] Calculated on average produce of 19 years, 1849-52 and 1856-70. [2] Probably crop too low owing to a dell.

*Potash in grain and straw of barley.*

this fact was assumed to be connected with the greater amount of the carbohydrate—sugar—in the roots than in the leaves. The results relating to the barley show, however, that there was in every case more, and in some much more, potash in the straw than in the grain. On this point it is to be observed, not only that the root-crop is taken up when still in the vegetative stage, and its contents are still in the condition of reserve or migratory material, whilst in the case of the cereal the crop is ripened, and its constituents are, therefore, more fixed. Further, whilst in the turnip-crop there was several times as much dry substance in the roots as in the leaves, in the barley there was even more dry organic substance in the straw than in the grain. Again, in both crops, by far the larger proportion of the dry substance consists of carbodyrates—in the one chiefly sugar, and in the other almost exclusively starch and cellulose—the latter making up by far the greater portion of the dry substance of the straw. It is obviously quite consistent that under these circumstances there should be more of the total potash of the barley crop accumulated in the straw than in the grain. It must at the same time be observed that, whilst the potash in the grain is comparatively fixed and bears a fairly uniform relation to the amount of dry substance, the quantity which remains in the straw is subject to great variation in proportion to the dry matter, according to the variation in the supply of it within the soil—a great excess above the amount in other cases being sometimes found in the straw. Indeed, the figures show a considerably greater proportion of the total potash of the crop accumulated in the straw where there was a liberal supply of it in manure.

*Effects of manures.*

Referring to the amounts of potash taken up in the rotation barley crops on the different plots, according to the manuring or other treatment, the figures show that there was not much difference between the amounts without manure and with superphosphate alone. There was, however, distinctly more taken up on the portions of the superphosphate plot where the roots had not been removed than where they were; and where, therefore, there was conservation for the succeeding crop. With the mixed manure, however, with its supply of potash as well as of phosphoric acid and nitrogen, the amount of potash in the crops is greatly increased, the increase corresponding closely with the increased amount of produce.

*Rotation and continuous crops.*

Lastly in regard to the potash, whilst without manure and with superphosphate alone the rotation barley has gathered much more than the continuously grown, with the mixed manure and full supply of all constituents, the amounts of

potash taken up were, as were those of nitrogen and phosphoric acid, nearly the same in the rotation and the continuous crops where in rotation the preceding roots had not been removed; but where they had been removed, the amounts of potash in the succeeding barley were less, as were the crops themselves.

*The Potash in the Leguminous Crops.*—Of all the mineral constituents of the crops, perhaps potash and lime are the most generally recognised as having some distinctive effects when applied as manure for leguminous crops. We have now to refer to the records relating to the potash in these crops, as given in the third division of Table 64.

*Potash in corn and straw of legumes.* The figures show that, in the case of the beans, unlike that of the cereals, there is much more potash in the corn than in the straw; indeed, more than twice as much of the potash of the crops was accumulated in the corn as in the straw; indicating, therefore, a special requirement of it for the formation of the final and most fixed product of the plant—the seed.

*Effects of manures.* Looking to the amounts of potash per acre in the total produce, corn and straw together, of the rotation beans, it is seen that they take up very little more under the influence of the superphosphate than without manure; the quantities averaging about 10 lb. per acre without manure, and scarcely 12 lb. with superphosphate. With the mixed manure, however, directly supplying potash for the previous root-crop, the amounts of it taken up were, in the one case 22.16, and in the other 24.46 lb., or about twice as much as with the superphosphate alone. The influence of the previous supply of potash on the amounts of it taken up in the beans was, in fact, much greater than was that of the supply of phosphoric acid on the amounts of it taken up.

*Rotation and continuous crops.* But, as in the case of the phosphoric acid, so also in that of the potash, the continuously grown beans took up only about half as much as those grown in rotation; proportionally more, however, where it had been supplied than where it had not. It will be remembered that, when discussing the amounts of produce of the bean crops, attention was called to the fact that throughout the experiments a really good agricultural crop was scarcely ever obtained; and this of course must be taken into account when considering the amounts of the several constituents of the crops.

*Clover and beans compared.* Comparing the amounts of potash stored up in the rotation clover with those in the rotation beans, it is seen that, even without manure and with very small produce, the clover, with its greater root-range and longer period of growth, gathered up about three times as much potash as the beans—about 30 lb. against only about 10 lb. in the beans.

With superphosphate alone, whilst the bean crops contained only 10.82 and 12.80 lb. of potash, the clover contained 57.63 and 65.48 lb. That is, under the influence of the phosphatic manure, probably partly on the plant and partly on the soil, the clover had accumulated in the removed crop five or six times as much potash as the beans, from the soil itself; whilst, of the phosphoric acid itself, little more than twice as much was taken up in the clover as in the beans under the influence of the superphosphate without potash. It would thus appear that the beneficial effects of the phosphatic manure on the clover were largely connected with the increased capability of the plant to take up more potash.

With the mixed manure, supplying a large amount of potash, the amount of it found in the clover crops was, however, much greater still. Both in the beans and in the clover the amount of potash in the crops grown under the influence of the direct supply of it was about twice as much as those grown with superphosphate without potash. But whilst, under the influence of the supply of it, the shorter-lived, more meagrely rooting, and less successfully grown bean crops stored up only 22.16 and 24.46 lb. of potash, the clover crops contained in one case 123.12 lb., and in the other 132.62 lb.

*Potash manures for leguminous crops.*

The very much larger proportion of the total potash of the bean crops which is found in the corn than in the straw would seem to indicate its greater importance in connection with the maturing than with the merely vegetative and accumulating tendencies of growth; yet the increased amount of it taken up by the beans coincidently with increased growth, and the much larger amounts of it in the clover with its much greater amounts of growth and produce, and harvested as it is in the unripened condition, are on the other hand indications of a direct connection between potash supply and the luxuriance of growth or vegetative activity of these leguminous crops. Indeed, as already referred to, potash manures are well known to be frequently beneficial to such crops. To these points further reference will be made presently, when calling attention to the amount of lime taken up by leguminous crops.

*The Potash in the Wheat Crops.*—The results on this point are given in the bottom division of Table 64.

*Potash in grain and straw of wheat.*

It has been seen that by far the larger proportion, both of the nitrogen and of the phosphoric acid of the wheat crops, was accumulated in the grain. But the figures relating to the potash show that of it there was very much more in the straw than in the grain. There was also much more, but not in so great a degree more, in the straw than in the grain of the other cereal—the barley. It has been pointed out that potash is at any rate essentially connected with the formation

of the carbohydrates. Consistently with this it was found that by far the larger proportion of the potash of the turnip crop was in the roots, where was the great accumulation of sugar. Again, of the total potash of the barley crop, the larger proportion was found in the straw where there was the greatest accumulation of carbohydrate—as cellulose; and now, in the wheat, with a larger proportion of straw to grain, and a proportionally larger amount of the total carbohydrates accumulated in the straw, we have in it a still larger proportion of the total potash of the crop. It is, however, to be borne in mind, as has been pointed out, that the straw of both barley and wheat frequently contains, besides the mineral constituents actually essential for the organic formations and changes, a more or less surplus amount taken up as the result of liberal supply, and retained by the plant.

*Functions of potash and phosphoric acid.*

Although there is doubtless clear foundation in fact for the conclusion that the *rôle* of phosphoric acid is more in connection with the formation and activity of the nitrogenous bodies, and that of the potash with those of the non-nitrogenous compounds, yet it is obvious that in such a view we have only a partial and imperfect explanation of the function of these mineral constituents. Thus, in the case of the beans there was, consistently enough, much more phosphoric acid in the corn than in the straw—that is, the more where there was the more nitrogen; but there was also by far the larger proportion of the potash accumulated in the corn, although the greater part of the dry matter of the crop, and with this of its carbohydrates, was in the straw. Indeed, although the leguminous crops are pre-eminently highly nitrogenous, a liberal supply of potash is essential for their luxuriance; whilst they contain a higher proportion of it in their dry substance than do the cereals, with their higher proportion of carbohydrates.

Reference to the figures shows that the application of superphosphate, without potash, enabled the wheat plant, whether grown in rotation or continuously, to take up an increased, but not a much increased, amount of potash, compared with that in the unmanured crops; and that the direct application of it increased the assimilation of it still further, though the increased amount of it stored up represented only a small proportion of that supplied in the manure.

*Rotation and continuous crops and the effect of manures.*

Without manure, the rotation wheat crops contained an average of about 27 lb. of potash, but the continuously grown ones scarcely 13 lb., or only about half as much. With superphosphate, without potash, the rotation crops gave an average of nearly 30 lb., and the continuously grown ones little more than 15 lb.; or, again, only about half as much. That is,

when the growing crops had to rely for their potash exclusively on the stores of the soil itself, the rotation crops took up about twice as much as the continuous. Lastly, with the mixed manure supplying potash, the rotation wheat crops gathered nearly 36 lb. after fallow, but about 38 lb. after the leguminous crops; whilst the continuously grown ones yielded an average of only about 27 lb. That is, although in the case of the rotation wheat crops three other crops had been grown since the application of the manure, they took up more potash than the continuously grown ones for which potash was annually supplied.

*Other mineral constituents.* So much for the results relating to the amounts of the two important and typical mineral constituents—phosphoric acid and potash—taken up by the different crops when grown, respectively, in rotation and continuously, under different conditions as to manuring, and other treatment. Similar results relating to other mineral constituents of the crops have been got out, and the discussion of some of them brings to view points of considerable interest, but neither time nor space will admit of their consideration here. It must suffice to refer briefly to the amounts of lime taken up by the leguminous crops under different conditions; a point which has an interesting relation to the results as to the potash taken up by those crops, and to the questions which arose in the discussion of them.

### *The Amounts of Lime in the Rotation, and in the Continuous Leguminous Crops.*

The following Table (65) gives, for the leguminous crops alone, the amounts of lime in the rotation and in the continuous crops, in the same form in which the phosphoric acid and potash have been given for each of the four crops of the rotation.

*Lime in corn and straw of beans.* Very different from what was found to be the case with the potash, it is seen that in the rotation bean-crops a very small proportion of the total amount of lime is accumulated in the corn; ten, twelve, or more times as much being found in the straw. Then, the amounts of lime in the total crops were—without manure between 15 and 16 lb.; with superphosphate, which of course supplied some lime, the quantity was raised to 18.68 and 20.71 lb.; and with the mixed manure, also supplying the same amount of lime in its superphosphate, it was further raised to 26.57 and 27.71 lb. *Rotation and continuous crops.* It is further seen, that the continuously grown beans contained—in corn, straw, and total produce—in some cases only about,

and in others not much more than, half as much lime as the rotation ones.

It is remarkable, however, that whilst without manure the rotation bean-crops contained only from 15 to 16 lb. of lime, the clover contained 67.84 and 59.10 lb.; with superphosphate the beans gave 18.68 and 20.71 lb., and the clover 158.62 and 184.52 lb. or about eight times as much as the beans; and lastly, with the mixed manure, the bean-crops contained 26.57 and 27.71 lb., and the clover 181.75 and 195.14 lb. of lime, or about seven times as much as the beans. *Effect of manures.*

TABLE 65.—Average amounts of Lime per acre per annum in the Rotation, and in the continuously grown, Leguminous Crops.

| | Unmanured. | | | | Superphosphate. | | | | Mixed mineral and nitrogenous manure. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | | Roots carted. | | Roots fed. | |
| | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover | Fallow. | Beans or clover |
| **BEANS (6 COURSES), CLOVER (2 COURSES), OR FALLOW.** | | | | | | | | | | | | |
| | | lb. | | lb. | | lb. | | lb. | | lb. | | lb. |
| Corn, Rotation | | 1.15 | | 1.14 | | 1.10 | | 1.32 | | 2.10 | | 2.38 |
| Corn, Continuous | | 0.47 | | 0.47 | | 0.52 | | 0.52 | | 1.24 | | 1.24 |
| Corn, Rotn. + or − cont. | | 0.68 | | 0.67 | | 0.58 | | 0.80 | | 0.86 | | 1.14 |
| Straw, Rotation | | 14.61 | | 14.66 | | 17.58 | | 19.39 | | 24.47 | | 25.33 |
| Straw, Continuous | | 7.85 | | 7.85 | | 9.36 | | 9.36 | | 15.08 | | 15.08 |
| Straw, Rotn. + or − cont. | | 6.76 | | 6.81 | | 8.22 | | 10.03 | | 9.39 | | 10.25 |
| Total, Rotation | | 15.76 | | 15.80 | | 18.68 | | 20.71 | | 26.57 | | 27.71 |
| Total, Continuous | | 8.32 | | 8.32 | | 9.88 | | 9.88 | | 16.32 | | 16.32 |
| Total, Rotn. + or − cont. | | 7.44 | | 7.48 | | 8.80 | | 10.83 | | 10.25 | | 11.39 |
| Total, Rotation | | 67.84 | | 59.10[1] | | 158.62 | | 184.52 | | 181.75 | | 195.14 |
| Total, Continuous | | ? | | ? | | ? | | ? | | ? | | |
| Average of 8 courses, beans and clover | | 28.78 | | 26.68[1] | | 53.67 | | 61.66 | | 65.36 | | 69.57 |

[1] Probably crop too low owing to a dell.

An increased amount of lime is, therefore, even more directly connected with increased luxuriance and increased production, than is an increased amount of potash taken up. Then, again, the increased amount of potash was apparently more or less directly connected with tendency to maturation or seed-formation; but the lime is found chiefly in the straw of the beans, and to be enormously increased in amount in the clover, which does not ripen, but is cut whilst still in the vegetative condition. The indication is, therefore, that the lime is, both actually and as compared with the potash, much *Function of lime in plant-growth.*

more directly connected with the accumulative or vegetative, as distinguished from the maturing processes of the plant. Certain it is, at any rate, that a largely increased accumulation of lime is a coincident of increased luxuriance in both crops; and it is especially so in the case of the crop the amount of which depends on the extension of the vegetative stages of development, and the production of a large amount of crude or unripened vegetable substance.

Thus, then, the actual and relative importance of potash and lime in the growth of the highly nitrogenous leguminous crops is clearly illustrated in the acreage amounts given, of potash in the third division of Table 64, and of lime in Table 65. But the study of the percentage composition of the ashes of the crops, and especially of both the percentage composition of the ashes, and the amount of the constituents per acre, in the bean plant taken at different stages of its growth, and of somewhat similar results relating to the first, second, and third crops of clover, affords further confirmation of the conclusions which have been drawn from the results already considered. It will be impossible to go into any detail here in regard to these further results, and it must suffice to state very briefly their general indications.

*Proportions of lime, potash, and carbonic acid in the ash of plants, and their relation to the assimilation of nitrogen.*

The bean-plant ash analyses showed that, on the average, about 75 per cent, and at the time of pod formation nearly 80 per cent, of the total ash consisted of lime, potash, and carbonic acid. Compared with these results, those relating to the more highly nitrogenous clover, which is not allowed to ripen, but is cut when it reaches the blooming stage, so inducing re-growth and extension of the more specially vegetative stages, show that from about 80 to about 84 per cent of the total ash consisted of lime, potash, and carbonic acid. But whilst in the ash of the ripened corn-yielding bean-crop there was about one and a-half time as much potash as lime, in that of the merely vegetating unripened clover there was twice or even three times as much lime as potash. Further, in the ash of the first and third crops of clover, which would be the most succulent and unripe, the relative excess of lime over potash is much greater than in that of the second crop, which develops at the period of the season when the seed-forming tendency is much the greater. Again, in the clover ashes there was about one and a-half time as much carbonic acid as in the ash of the ripened bean plant. It is thus further illustrated that a peculiarity of the composition of these pre-eminently nitrogen-assimilating elements of rotation is, that their ashes consist chiefly of lime, potash, and carbonic acid; that the potash predominates in the ripened and less nitrogen-yielding bean-crop; and that

the lime and carbonic acid predominate in the continuously vegetating and much more largely nitrogen-accumulating clover.

Referring to the probable or possible significance of these facts, it is obvious that, so far as the nitrogen of the plant is taken up as nitrate of a fixed base, that base, so far as it does not pass back into the roots, will remain in the above-ground parts of the plant, most probably in combination with an organic acid, which will be converted into carbonic acid in the incineration, and be found as such in the ash, if not expelled by an excess of fixed acid, or by silica.

*Nitrogen taken up by plants as nitrate.*

In the case of the cereals of the rotation, it is probable that most, if not all, of their comparatively small amount of nitrogen is taken up as nitrate. Potash is by far the predominating base in the ash of the grain, straw, and total produce; lime is in much less amount, both actually and in equivalency; and magnesia is in less amount still, though it is a characteristic constituent of the grain-ashes. There is practically no carbonic acid in either wheat or barley grain-ash, and but little in the straw-ash; and if there have been organic acid salts formed with the base of the nitrate, the carbonic acid may have been expelled in the incineration, by the excess of fixed acid in the grain-ash, or by silica in the straw-ash.

Taking the produce by the mixed manure as the most normal, the root-crops of the rotation come next in amount of nitrogen assimilated over a given area. Potash and lime are the predominating bases. There is much more potash than lime in the more definite product—the root; but the proportion of lime to potash is much greater in the leaf-ash, as would be expected if the nitrogen had been taken up chiefly as calcium nitrate, and the nitric acid subjected to decomposition in the leaves.

Lastly come the Leguminosæ, with their much higher amounts of nitrogen assimilated. These plants also doubtless derive at any rate much nitrogen from nitrates in the soil and subsoil; and it has been shown that their great assimilation of nitrogen is associated with very large amounts of lime and carbonic acid in their ashes.

Referring to the results with the rotation beans grown by the mixed manure, calculation shows that, taking the total crop, corn and straw together, it contained very much less lime than would be required if the whole of its nitrogen had been taken up as calcium nitrate; so that either part of the nitrogen must have been taken up as nitrate of some other base, or in some quite different state of combination, or as free nitrogen; or some of the lime must have been elimin-

ated from the above-ground parts of the plant into the roots, and possibly some of it passed from them into the soil. Again, the amount of carbonic acid found in the ashes of the crop for 100 of nitrogen in it would require about one and a-half time as much lime as was found in association with it; indicating the probability that part of the nitrogen taken up as nitric acid was as the nitrate of some other base—potash, and possibly to some extent soda also.

Turning to the results with the rotation clover grown by the mixed manure, calculation shows that in the case of this continuously vegetating, unripened, and much higher nitrogen-yielding crop, there was very much more of both lime and carbonic acid in the ash for 100 of nitrogen assimilated than in the total bean-crop. If, however, the whole of the nitrogen of the clover crops had been taken up as calcium nitrate, it would have required nearly twice as much lime as the amount found, provided the whole of it remained; nor would the amounts of potash and soda found suffice to make up the balance. Again, the amount of carbonic acid found is little more than two-thirds as much as would be required to represent organic acid equivalent to the amount of nitric acid subjected to change. Either, therefore, fixed base, partly in combination with organic acid, must have been eliminated from the above-ground parts of the plant, and passed into the roots, and possibly into the soil, or a good deal of the nitrogen must have been taken up in some other form than as nitrate; possibly in part as organic nitrogen taken up from the soil by the agency of the acid sap; or, in part as free nitrogen, probably brought into combination under the influence of micro-organisms within the nodules found on the roots of leguminous plants, the resulting compound being either directly available as a source of nitrogen to the host, or it may be so only after it has itself suffered change.

*Lime as a carrier of nitric acid.* However this may be, considering the very characteristic differences in the mineral composition of the different crops of rotation according to the amounts of nitrogen they assimilate, the fact that undoubtedly the highly nitrogenous Leguminosæ do take up at any rate a large proportion of their nitrogen as nitrate, and that the greater the amount of nitrogen assimilated the more is the ash characterised by containing fixed base, and especially lime, in combination with carbonic acid, it seems very probable, if not indeed established, that the office of the lime, and partly that of the other bases also, is that of carriers of nitric acid; which, when transformed, and the nitrogen assimilated, leaves the base as a residue, presumably in combination with organic acid. Further, the power of these plants to assimilate so very much

more nitrogen over a given area than the other crops may, at any rate in part, be dependent on their being able, by virtue of the range and character of their roots, to gather up more nitrogen in the form supposed than the plants with which they are alternated. Such a view does not, however, exclude the supposition that some of their nitrogen is derived in other ways, as above referred to.

*Applications of lime and potash for leguminous crops.*

In connection with the foregoing results of direct experimental investigation into the mineral composition of leguminous crops, it may be observed—that clover at any rate grows more favourably on land that has recently been chalked or limed; that chalking or liming of the mixed herbage of grass land also favours the development of the leguminous herbage; and that the application of gypsum to clover has been found very effective on some lands, especially in America, though it has not proved to be at all generally useful when it has been so applied in this country. Indeed, the direct application of potash as manure is certainly more frequent, and is more generally recognised as effective for leguminous crops, than is that of lime, notwithstanding its obvious importance, and its great influence on the luxuriance of growth of such crops. This may perhaps be partly explained by the fact that, in many, if not in most, soils, the immediately available supply of potash within the root-range of the plant will probably be sooner exhausted than will that of lime.

## Summary and General Conclusions.

It remains, in conclusion, very briefly to summarise the facts brought out in this extended inquiry on the subject of rotation, and to endeavour to draw from them an explanation of the benefits arising from the practice of it.

*Variations in rotations.*

At the commencement it was pointed out, that although many different rotations are adopted, they may for the most part be considered as little more than local adaptations of the system of alternating root-crops and leguminous crops with the cereals. Thus, there are rotations of five, six, seven, or more years. But these variations are, in most cases, only adaptations of the principle to variations of soil, altitude, aspect, climate, markets, and other local conditions; and they consist chiefly in the variation in the description of the root-crop, and perhaps the introduction of potatoes; in growing a different cereal, or it may be more than one cereal consecutively; in the growth of some other leguminous crop than clover; or the intermixture with the clover of grass seeds; and perhaps the extension of the period allotted to this element of the rotation to two or more years.

*Removal of home consumption of crops.* It is true, also, that, under any specific rotation, there may be deviations from the plan of retaining the whole of the root-crop, the straw of the grain crops, and the leguminous fodder-crops, on the farm, for the production of meat or milk, and, coincidently, for that of manure to be returned to the land. But it is also true that, when under the influence of special local, or other demand—proximity to towns, easy railway or other communication, and so on—the products which would otherwise be retained on the farm are exported from it, the import of town or other manures is generally an essential condition of such practice. Indeed, this system of free sale very frequently involves full compensation by purchased manures of some kind. In our own country, such deviations from the practice of merely selling grain and meat have been much developed in recent years; and they will doubtless continue to increase under the altered conditions of our agriculture, dependent on very large imports of grain, increasing imports of meat and other products of feeding, and very large imports of cattle-food and other agricultural produce. Already much more attention is being devoted to dairy products, not only on grass farms, but on those that are mainly arable; and there will doubtless be some, but probably by no means so great an extension as some suppose, in the production of other smaller articles required by town populations.

*Exceptional rotations.* It is further true, though the remark applies in a very limited degree to our own country, that there are other deviations which have more the character of exceptions to the general rule of rotation, such as the introduction of flax, hemp, tobacco, or other so-called *industrial* crops. But, in these cases, as with potatoes, the growth involves special expenditure for manure instead of conservation of it. Indeed, the inducement is the high price of the product, rather than the maintenance, or the improvement, of the condition of the land for future crops.

*Self-supporting rotations.* Still, as such deviations from regular rotation practice as have been referred to, do, as has been said, generally involve more or less, and frequently full, compensation by manure from external sources, we may, in endeavouring to explain the benefits which accrue from the practice of rotation, confine attention, for the purposes of illustration, to what may be called the self-supporting system, and to the simple four-course one which has been selected for investigation at Rothamsted, and from the results relating to which the illustrations which have been brought forward have been drawn.

*Mineral constituents in rotation crops.* It will be well first briefly to refer to the evidence relating to some of the more important mineral constituents found in the different crops of the four-course rotation.

Of *phosphoric acid*, the cereal crops take up as much as, or more than, any of the other crops of the rotation, excepting clover; and the greater portion of what they take up is lost to the farm in the saleable product—the grain. The remainder, that in the straw, as well as that in the roots and the leguminous crops, is supposed to be retained on the farm, excepting the small amount exported in meat and milk. *Phosphoric acid.*

Of *potash*, each of the crops takes up very much more than of phosphoric acid. But much less potash than phosphoric acid is exported in the cereal grains, much more being retained in the straw; whilst the other products of the rotation —the roots and the Leguminosæ—which are also supposed to be retained on the farm, contain very much more potash than the cereals, and comparatively little of it is exported in meat and milk. The general result is, that the whole of the crops of rotation take up very much more of potash than of phosphoric acid, whilst probably even less of it is eventually lost to the land. *Potash.*

Of *lime*, very little is taken up by the cereal crops, and by the roots much less than of potash; more by the Leguminosæ than by the other crops, and, by the clover especially, sometimes much more than by all the other crops of the rotation put together. Of the lime of the crops, however, very little goes in the saleable products of the farm under the conditions supposed of a self-supporting rotation. There is, however, frequently a considerable loss of lime in land-drainage. *Lime.*

Although the facts relating to other mineral constituents of the crops are not without significance, reference can be made here to only one other of these constituents—namely, the *silica*.

The interpolated crops of rotation—the roots and the Leguminosæ—take up scarcely any silica; but the cereals take up a very large amount of it. Indeed, the large amount of silica taken up by these crops when grown under ordinary conditions, is as characteristic a chemical phenomenon of rotation as is the very large amount of lime taken up by clover and other Leguminosæ. Very little silica, however, is lost to the land in the assumed saleable products. *Silica.*

Thus, then, although different, and sometimes very large, amounts of these typical mineral constituents are taken up by the various crops constituting the rotation, there is no material export of any in the saleable products, excepting of phosphoric acid and of potash; and, so far at least as phosphoric acid is concerned, experience has shown that it may be advantageously supplied in purchased manures. *Loss and return of mineral constituents.*

But, although the eventual loss to the land of mineral constituents is, in a self-supporting rotation, comparatively so

*Importance of mineral constituents.* small, the very fact that the different crops require for their growth, not only very different amounts of individual constituents, but require these to be available within the soil in very different conditions, both of combination and of distribution, points to the conclusion that, in any explanation of the benefits of an alternation of crops, the position, and the *rôle*, of the mineral constituents must not be overlooked; and the less can it be so, when their connection with the very important element—the nitrogen of the crops—is considered.

*Nitrogen in rotation crops.* As to the *nitrogen*:—It has been seen that, although very characteristically benefited by nitrogenous manures, the cereal crops take up and retain much less nitrogen than any of the crops alternated with them. In fact, the root-crops may contain two, or more, times as much nitrogen as either of the cereals, and the leguminous crop, especially the clover, much more than the root-crops. The greater part of the nitrogen of the cereals is, however, sold off the farm; but perhaps not more than 10 or 15 per cent of that of either the root-crop, or the clover, or other forage leguminous crop, is sold off in animal increase or milk. Thus, most of the nitrogen of the straw of the cereals, and a very large proportion of that of the much more highly nitrogen-yielding crops, returns to the land as manure, for the benefit of future cereals and other crops. Indeed, it is, as a rule, only a comparatively small proportion of the very much increased amount of nitrogen obtained in rotation compared with that in continuous cereal-cropping (chiefly due to the interpolated crops), that is lost to the land in the saleable products.

*Assimilation of nitrogen by roots.* As to the source of the nitrogen of the so-called "restorative crops," it has been shown that certainly in the case of the roots it is not, as has sometimes been assumed, that such plants take up nitrogen from the air by virtue of their extended leaf-surface. Both common experience and direct experiment demonstrate that they are as dependent as any crop that is grown on available nitrogen within the soil, which is generally supplied by the direct application of nitrogenous manures—natural or artificial. Under such conditions of supply, however, the root-crops, so to speak, gross feeders as they are, and distributing a very large amount of fibrous feeding root within the soil, avail themselves of a much greater quantity of the nitrogen supplied than the cereals would do under similar circumstances; this result being partly due to their period of accumulation and growth extending even months after the period of collection by the ripening cereals has terminated, and at the season when nitrification within the soil is the most active, and the accumulation of nitrates in it is the greatest. Lastly, full supply of both mineral con-

stituents and nitrogen being at command, these crops assimilate a very large amount of carbon from the atmosphere, and produce, besides nitrogenous food products, a very large amount of the carbohydrate—sugar—as respiratory and fat-forming food for the live-stock of the farm.

*Assimilation of nitrogen by maize.*

Very much the same may be said of maize as grown as a fodder-crop in America, as of roots as grown in rotation in other countries. Thus, there can be no doubt that the maize derives its nitrogen from the soil, collecting some time longer than wheat, and availing itself of the nitrates formed after the collection by the wheat has ceased. But, so far as the product is consumed on the farm, much of its nitrogen is recovered in the manure—the more when the food is used for growing or fattening stock, and the less when for the production of milk.

*Leguminous crops and the supply of nitrogen in the soil.*

The still more highly nitrogenous leguminous crops, on the other hand, although not characteristically benefited by nitrogenous manures, nevertheless contribute much more nitrogen to the total produce of the rotation than any of the other crops comprised in it. It is also certain that, at any rate a large proportion of the nitrogen of these crops is obtained from the soil and subsoil; though recent investigations have proved that some of their nitrogen, and sometimes much of it, may be derived indirectly from the free nitrogen of the atmosphere, brought into combination under the influence of micro-organisms within the nodules on the roots of the plants.

It is the leguminous fodder crops, and among them especially clover, which has a much more extended period of growth, and much more extended range of collection within the soil and subsoil, than any of the other crops of the rotation, that yield in their produce the largest amount of nitrogen per acre. Much of this is doubtless taken up as nitrate; yet, the direct application of nitrate of soda has comparatively little beneficial influence on their growth. The nitric acid is probably taken up chiefly as nitrate of lime, but probably as nitrate of potash also, and it is not without significance that the high nitrogen-yielding clover takes up, or at least retains, very little soda. The general result is, then, that although undoubtedly the clover takes up a good deal of its nitrogen as nitrate, this would seem to be derived from accumulations within the soil, which are brought into suitable conditions of combination, and distributed through a wide range of soil and subsoil.

*Nitrate of soda and clover.*

*Sources of nitrogen for clover.*

So much, then, for the benefits of rotation, so far as the requirements, the habits of growth, and the capabilities of

*Relation of rotation to economical manuring.* gathering and assimilating the various mineral constituents, and the nitrogen, of the different crops, are concerned. It cannot be doubted that the difference in the amounts, in the conditions of combination, and in the distribution within the soil, of the various mineral constituents, is at least an element in the explanation of the benefits of alternation; nor, on the other hand, can there be any doubt that the facts relating to the amount, and to the sources, of the nitrogen of the different crops, are of still greater significance than are those in regard to the mineral constituents.

*Rotation and sale of produce.* But, it is not only the conditions of growth, but the *uses* of the different crops when grown, that have to be taken into account. Thus, the cereals, when grown in rotation, yield more produce for sale in the season of growth than when grown continuously. Again, the crops alternated with them accumulate very much more of mineral constituents and of nitrogen in their produce, than do the cereals themselves; and, by far the greater proportion of those constituents remains in circulation in the manure of the farm, whilst the remainder yields highly valuable products for sale in the forms of meat and milk.

Further, independently of the benefits arising from the difference in the requirements and results of growth of the different crops, of the increased amount of manure available, and of the increased sale of highly valuable animal products, there are other elements of advantage of considerable importance. *Rotation and distribution of labour.* For example, with a variety of crops, the mechanical operations of the farm, involving horse and hand labour, are better distributed over the year, and are therefore more economically performed. Last, but by no means least, the *Rotation and cleaning land.* opportunities which alternate cropping affords for the cleaning of the land from weeds is a prominent element of advantage.

Thus, then, the benefits of rotation are very various; and the explanation of them, though largely dependent on the facts which have been ascertained by scientific investigation, also largely involves considerations connected with the general economy of the farm; and since, as has been seen, so large a proportion of the produce grown is retained on the farm, as stock-food or litter, it is obvious that the benefits cannot be fully appreciated without arriving at some definite idea of the importance to the farmer of the saleable animal products, and of the manure obtained. This subject will be considered in Section VI., which now follows.

## *SECTION VI.—THE FEEDING OF ANIMALS FOR THE PRODUCTION OF MEAT, MILK, AND MANURE, AND FOR THE EXERCISE OF FORCE.*

### Introduction and History.

*Stock-feeding in rotation farming.*

It was shown in the last Section (V.), on the Rotation of Crops, that any explanation of the benefits of rotation is quite inadequate which does not take into account the results of the feeding of the animals on the farm. Thus, in the discussion of the amounts of the produce of the various crops grown in alternation with one another, and of the amounts of the various constituents of the individual crops, or of their separate parts, it was pointed out that only certain portions of them were at once available as saleable products; a large proportion remaining for use on the farm in some way, and only eventually yielding a profitable return.

*Constituents of crops removed from and retained on land.*

The extent to which the retention on the farm of the constituents accumulated in the crops may take place, may usefully be illustrated by reference to a particular example, which will convey a clearer conception of the importance of the subject than any mere general statement can do. Accordingly, in Table 66 is given an approximate estimate of the proportion of certain selected constituents of the crops grown in the typical four-course rotation of swedish turnips, barley, leguminous crop, and wheat, which would be at once sold off the farm, and of the amounts retained upon it; supposing that only the grain of the cereals is sold, and that the root-crop, the leguminous crop, and the straw of the cereals, are retained for further use. The estimates are

TABLE 66.—Illustration of the Proportion of the Constituents of Crops grown in Rotation, at once sold off the Farm, and of those retained upon it for further use.

| | Per cent of total in the crops. | |
|---|---|---|
| | At once sold off the farm. | Retained on the farm for further use. |
| | per cent. | per cent. |
| Dry matter | 30.6 | 69.4 |
| Nitrogen | 43.4 | 56.6 |
| Total mineral matter (ash) | 14.5 | 85.5 |
| Phosphoric acid | 56.2 | 43.8 |
| Potash | 20.0 | 80.0 |

founded on the average amounts of produce obtained, over eight courses, in the fully manured rotation, the particulars of which were given and discussed in the paper on Rotation above referred to.

It is true that the exact figures given in the table have only reference to a particular case, and that in practice there will sometimes be larger and sometimes smaller proportions of these constituents of the crops at once sold, or retained on the farm. Nevertheless, the illustrations may be taken as essentially typical, and as so far conveying a very useful impression on the subject.

*Produce retained for stock-feeding.*

Referring to the figures, the question arises—To what beneficial or profitable purposes are about two-thirds of the total vegetable substance grown, more than half its nitrogen, nearly half its phosphoric acid, and about four-fifths of its potash, retained on the farm? Briefly stated, it is *for the feeding of animals for the production of meat, milk, and manure, and for the exercise of force—that is, for their labour.* It is, then, the facts, and the principles, involved in the feeding of the animals of the farm for these various purposes, that we have now to consider.

*Increased production and economical feeding.*

It is obvious that, so long as a country is only sparsely populated, and the needs of the people are amply supplied under a comparatively rude system of agriculture, in which extended area precludes the necessity for improved methods, there would be little either of scope or of inducement to study economy in the feeding of animals, or to systematic practice in regard to it. But as population increases in proportion to area, there arises the necessity for increased production over a given area. It was pointed out in our paper on Rotation that, in our country, gradually a greater variety of crops came to be grown; that first leguminous crops, and then root-crops, were introduced, and finally the system of rotation became general. Thus, a much greater variety, and a much greater quantity, of home-produced stock-foods became available; and in time foods of various kinds were imported from other countries.

Somewhat similar changes in their food resources occurred in various parts of the Continent of Europe; and with these came the inducement, if not the necessity, to pay more attention to the subject of feeding. The end was, however, sought to be attained by somewhat characteristically different methods in our own country and on the Continent. With us, more special attention was paid to the improvement of the breeds of the farm animals themselves—not only to enhance the development of the most valuable characters in the final product, but to secure early maturity, and thus materially

*Improvement in live stock.*

to economise the expenditure of food in the mere maintenance of the living meat-and-manure-making machine. As to the use and adaptation of different foods, but little systematic inquiry was undertaken in regard to it, each feeder relying largely on his own judgment, or on the unwritten rules adopted in his locality, as the result of practical experience.

*Continental feeding researches.*

On the Continent, however, and especially in Germany, much more attention was paid to the character of the food than to that of the animal; and towards the end of the last century and the beginning of this, much was devoted to determining the comparative value of different foods; and tables were constructed in which, adopting hay as the standard, it was attempted to arrange all other foods according to their supposed value compared with that standard. The plan was, to give the amount of each food which it was estimated was equivalent in food-value to 100 parts of hay.

*Thaer's hay values.*

The first comprehensive tables of *hay values* were constructed by Thaer, and were published by him in 1809. His operations, experiments, and writings, were of an essentially practical character. His estimates of so-called "hay values" seem, however, to have been based to some extent on the determinations of the supposed nutritive contents of different foods which had been made by Einhof; but partly also on his own determinations, and partly on direct feeding experiments. In these he sought to ascertain how much of the respective foods was required to substitute a given quantity of hay in the daily ration of the animals. His estimates were at any rate controlled by such experiments, and he states that their results upon the whole tended to confirm the conclusions arrived at by analysis.

Other writers also published tables of hay values, or hay equivalents, of foods. In some of these the results of new experiments, sometimes analytical, and sometimes practical, were embodied; but it is obvious from the identity of the figures in many cases, that they were largely compilations, one from another.

*Boussingault's investigations.*

Such was the condition of knowledge on the subject when Boussingault commenced his investigation of it soon after 1830. Like Thaer, Boussingault had the advantage of being a practical agriculturist; but whilst Thaer looked at the question of the feeding of the animals of the farm almost exclusively from the practical point of view, Boussingault approached it mainly from that of the chemist and the physiologist, though he, at the same time, made direct experiments with farm animals, and so arranged and conducted them as not only to elucidate some points of special scientific interest, but also to afford data which might serve both for

the explanation and for the improvement of agricultural practice.

Thus, besides contributing much towards a better knowledge of the actual and comparative value of different foods, he investigated the question whether animals either availed themselves of the free nitrogen of the air as a source of some of their nitrogen, or eliminated either free or combined nitrogen by the lungs or skin; also whether the fat stored up by the fattening animal was exclusively derived from the already formed fat of the food, or whether it was produced within the body, from other constituents of the food.

From the point of view of the practical agriculturist, Boussingault seems fully to have assumed the utility of attempting to arrange stock-foods according to their nutritive value compared with that of hay as a standard; and, in fact, this idea has given a direction to much subsequent investigation also.

*Nitrogen in foods.*

The first great advance made by Boussingault was, however, to determine the nitrogen in a large number of different foods; and, taking the amount of it as for the time the best measure of nutritive value, on this basis to compare them with hay. That is to say—supposing 100 parts of average good hay to contain a certain amount of nitrogen, how much of each of the other foods would be required to supply the same amount of it? These amounts would, on the supposition adopted, represent the quantities by weight in which one food may be substituted for another, and they may be considered as the theoretical equivalents of 100 of hay. Accordingly, he determined the nitrogen in about seventy-six different descriptions of food, which at that date involved a truly enormous amount of labour.

*Feeding experiments.*

Further, he selected a few typical articles of food for comparative feeding experiments, so as to be able to compare the results obtained both with those indicated by theory according to their contents of nitrogen, and with the estimates of others, founded chiefly on somewhat similar practical trials. He obviously fully recognised the difficulties and uncertainties of such modes of experimenting, and took great care to obviate error arising from them.

He discussed the general results of some experiments with milking cows; but gave in some detail the particulars and results of ten experiments with the horse. The normal food being hay, straw, and oats, he, in one case, substituted half the hay by potatoes, in another by Jerusalem artichokes, in another by mangels, in another by ruta-baga, and in another by carrots. Again, in another the straw and oats were replaced by potatoes; in another half the hay was replaced by

more oats and straw, and so on. In each case he noted the change in weight, and in the condition of the animals in other respects, if any; and he judged accordingly, whether the amount of food given in substitution was too much or too little, and whether, therefore, the practical or the theoretical results were the most to be relied upon.

He brought together in a table[1] the estimates of the value compared with 100 of hay, of the 76 different articles of food according to the amount of nitrogen he found in them; and side by side he gave the hay value of the foods according to the published estimates of others, and to the results of his own practical trials.

*Digestible and indigestible nitrogenous and non-nitrogenous substances in foods.*

Subsequently, however, Boussingault was not satisfied with his results so obtained, and he pointed out that what was still wanting was the determination of the amount of the various non-nitrogenous constituents also, and of how much of them was digestible, and how much indigestible; and eventually he determined in ninety different food-stuffs, not only the nitrogen, but the mineral matter, the woody fibre or cellulose, the fatty matter, and (probably by difference) the remaining non-nitrogenous matters, which he recorded as starch, sugar, and allied bodies. As to the nitrogen, he still, as formerly, multiplied the amount found by 6.25 to represent albumin, legumin, or casein.

He also still took 100 parts of hay as the standard by which to compare the nutritive value of other foods; as, for ruminants and horses, he considered it a good standard food, and that the relation in it of the nitrogenous and the digestible non-nitrogenous constituents was fairly normal. He now, however, modified the meaning of the equivalent arrived at, by taking into account the amount of digestible non-nitrogenous substance associated with the standard amount of nitrogen in each case; and, if there were a deficiency, he stated how much of some food rich in digestible non-nitrogenous matters should be added to complete the equivalent, and so make it comparable with the 100 of hay. Indeed, he now laid it down that equivalent rations must contain equal amounts of digestible non-nitrogenous as well as of the nitrogenous bodies.

*Equivalent rations.*

In the case of the ninety descriptions of food which he analysed as above referred to, he gave a table[2] recording the results obtained, and then showed the amount of each food required to contribute the same quantity of nitrogenous substance as 100 of hay. Next, he calculated how much nutritive non-nitrogenous matter, reckoned as carbohydrate

[1] *Rural Economy*, &c. English edition, 1845. H. Baillière, London.
[2] *Économie Rurale*, deuxième edition, 1851, vol. ii. pp. 356-363. Paris.

of 42 per cent carbon, was supplied in the amount of each food containing the nitrogen of 100 of hay. If the amount were less than in 100 of hay, he calculated how much straw was required to supply the deficiency, assuming straw to contain 45 per cent of such matter. The final result showed, not only the same amount of nitrogenous, but as much of digestible non-nitrogenous substance also, as 100 of hay. If, however, the nitrogen equivalent of the food contained an excess of digestible non-nitrogenous constituents, he did not make any corresponding deduction from the ration.

*Classification of foods.*

Boussingault fully recognised that food equivalents so calculated are only satisfactory in comparing foods of the same description, which he classified generally as follows:—

1. Hays and straws.
2. Roots and tubers.
3. Oily seeds.
4. Cereal grains, leguminous seeds, oilcake, &c.

*Application of Boussingault's tables.*

He pointed out that when the application of the tables is thus limited, they are very useful in showing how one food may be advantageously substituted for another of the same class, according to relative abundance, cheapness, and so on.

*Importance of Boussingault's investigations.*

In conclusion in regard to Boussingault: in giving a sketch of the history of the progress in our knowledge of the subject of the feeding of the animals of the farm, it was only due to him to give prominence to his enormous, painstaking, and most conscientious labours in regard to it. This is the case, independently of any direct applicability of his results and conclusions at the present time, because he was essentially the pioneer, and his conceptions and methods have had a very marked influence on the direction of subsequent investigations.

*Liebig's work.*

It was in 1842—that is, after Boussingault's first systematic discussion of the subject, but before his second—that Liebig published his work entitled *Chemistry in its applications to Physiology and Pathology.* In it he treated of food in its relations to the various exigencies of the animal body; and, apparently impressed, as was Boussingault, with the fact that nitrogenous constituents were both essential and characteristic of the animal body, and that they must therefore be supplied in the food they consumed, and in the case of the herbivora, in vegetable food-stuffs, he also, like Boussingault, indeed, probably directly influenced by his results and conclusions, himself concluded that the comparative values of food-stuffs as such were, as a rule, measurable by their richness in the nitrogenous, rather than in that of the non-nitrogenous constituents—

that is to say, more by their flesh-forming than by their more specially respiratory or fat-forming capacities. Thus he says (p. 45):—

*Liebig on the nitrogenous constituents of foods.*

Chemical researches have shewn, that all such parts of vegetables as can afford nutriment to animals contain certain constituents which are rich in nitrogen; and the most ordinary experience proves that animals require for their support and nutrition less of these parts of plants in proportion as they abound in the nitrogenous constituents.

Again, at p. 369 of the third edition of his *Chemical Letters* (1851), he says:—

The admirable experiments of Boussingault prove, that the increase in the weight of the body in the fattening or feeding of stock (just as is the case with the supply of milk obtained from milch cows), is in proportion to the amount of plastic constituents in the daily supply of fodder.

Liebig would probably be somewhat biassed in favour of the conclusion here stated, by the view he held—that the amount of force exercised in the animal body was measurable by the amount of nitrogenous substance transformed, and this again by the amount of urea found in the urine. To Liebig's views on this latter point, as well as on the question of the sources in the food of the fat of the animal body, and on some other points of scientific as well as practical interest, reference will be made further on, when considering each of these several questions independently. In the meantime our special object is to show, what were the prevailing opinions on the subject of the adaptation of foods according to their composition, to the sum of the requirements of the animals of the farm, which includes not only those for the mere maintenance of the body, but those for increase in live-weight, for the production of milk, or for the exercise of force, as the case may be. It was, however, not only in regard to the foods of the animals of the farm, but to human foods also, that the system of estimating their comparative value according to their percentage of nitrogen came to be applied. Thus, different descriptions of flour and bread, and numerous other aliments, both vegetable and animal, were examined, and their comparative food-values were assumed to be indicated by their richness in nitrogen.

## THE ROTHAMSTED FEEDING EXPERIMENTS.

*Rothamsted feeding experiments begun in 1847.*

It was in 1847, after Boussingault had published his first tables of the comparative nutritive values of different foods, founded on their percentage of nitrogen, and after Liebig had substantially endorsed Boussingault's conclusions on the point,

that systematic feeding experiments were commenced at Rothamsted. In the arrangement of them, the settlement of the questions raised by the experiments and conclusions of Boussingault, and by the enunciation of the theoretical views of Liebig, was kept prominently in view. But the plans adopted were, in some points, characteristically different from those adopted by Boussingault, and even more so from those which, as we shall see further on, have been generally followed by subsequent experimenters.

*Plan adopted.*

*Continental and other experiments.*

In Boussingault's feeding experiments he sought to ascertain the comparative values of different foods by trials with animals which were, as far as possible, maintained in an uniform condition, both as to weight and other circumstances, but which were, nevertheless, living and feeding under the normal conditions of such animals, for example a cow yielding milk, or a horse performing work. A vast amount of careful experiment has, however, since been devoted by others to determine the food requirements of a given live-weight for mere sustenance or maintenance; that is, not only without either loss or gain, but exclusively of the yield of milk, increase in live-weight, or the exercise of force; and then, as a separate question, to determine in the case of animals feeding for the production of meat, how much of the different constituents of food is required to be supplemented to the mere sustenance ration, to obtain the maximum increase for the minimum expenditure of the different food-constituents.

*Details of Rothamsted plan of experiments.*

Our own plan was, on the other hand, in the case of animals fed for the production of meat, to select foods of recognised value for such animals; to give a fixed quantity daily, of one or more, and to allow the animals to take, *ad libitum*, of some other or complementary food; the object being, excepting in certain cases for comparison, to secure that they should yield normal or full increase in weight, and that the results should indicate to what constituent, or class of constituents, in the food, the actual and comparative results were to be attributed.

*Characteristics of the plan.*

It will be seen that, under such a plan, the animals practically fixed their own consumption, according to the composition of the foods, and to their requirements; and that, the amounts of food, or of its various constituents consumed, covered the requirements, both for mere maintenance, and for the growth and fattening increase, as the case might be. It was thought that results so obtained, being comparable with those of actual practice, would supply important data for the elucidation of the principles involved in such practice.

*Animals experimented upon.*

Several hundred animals—oxen, sheep, and pigs—have been experimented upon. In the greater number of cases, and

especially in the earlier years, it was, owing to the amount of labour involved, found to be impracticable to do more in the way of analysis of the foods than to determine in them the percentages of dry substance, of mineral matter, of nitrogen, and sometimes of fatty matter. From the results were calculated the amounts of total nitrogenous substance, of total non-nitrogenous organic substance, and of total organic matter, which the food supplied. *Analysis of foods.*

At that time little or nothing had been done in the way of determining, either the condition of combination of the nitrogen in vegetable foods, or the character of the non-nitrogenous bodies. The only method then practicable was, to calculate the amount of nitrogenous substances from the amount of nitrogen, a plan which we pointed out was liable seriously to mislead, if due allowance were not made for differences in the composition, and condition, of the substances so estimated. In the case of ripened final products, such as cereal grains, and the leguminous seeds, there is comparatively little error in so reckoning the whole of the nitrogen to exist as albuminoid bodies; in hays and straws there is a much larger proportion of the total nitrogen non-albuminoid; and in succulent products, such as roots and tubers, much more still. *Calculating nitrogenous and non-nitrogenous constituents.*

Then, again, the proportion of the non-nitrogenous organic substance which is digestible is very different in different vegetable products. Thus, in hays and straws there is a large proportion of indigestible woody fibre, in cereal grains and leguminous seeds much less, and in roots and tubers very little. *Digestible and indigestible constituents.*

We shall, nevertheless, find that when, as was always done in our interpretation of the results, due reservation is made as to the character, both of the so-reckoned nitrogenous and of the non-nitrogenous organic substance of the different foods, the indications are very clear and significant as to whether, taking our fattening food-stuffs as they go, their comparative food-value is measurable, more by their contents in digestible nitrogenous, or in digestible non-nitrogenous, constituents.

The investigations also involved the determination of the composition, and especially of the amounts and the proportion of the nitrogenous, and of the non-nitrogenous constituents, in the bodies of the animals themselves, and in their increase whilst fattening; and it also involved that of the composition of the excrements, that is, of the manure. *Composition of animals' bodies and excrements.*

Thus, the inquiry embraced the following points:— *Points embraced in the feeding experiments.*

1. The amount of food, and of its several constituents, consumed in relation to a given live-weight of animal, within a given time.

2. The amount of food, and of its several constituents, consumed to produce a given amount of increase in live-weight.

3. The proportion, and relative development, of the different organs or parts of different animals.

4. The proximate and ultimate composition of the animals, in different conditions as to age and fatness; and the probable composition of their increase in live-weight during the fattening process.

5. The composition of the solid and liquid excreta (the manure) in relation to that of the food consumed.

6. The loss or expenditure of constituents by respiration and the cutaneous exhalations—that is, in the mere sustenance of the living meat-and-manure-making machine.

7. The yield of milk in relation to the food consumed to produce it; and the influence of different descriptions of food on the quantity, and on the composition, of the milk.

As already said, several hundred animals, oxen, sheep, and pigs, have been submitted to experiment.

The amount, and the relative development, of the different organs or parts were determined in 2 calves, 2 heifers, 14 bullocks, 1 lamb, 249 sheep, and 59 pigs.

The percentages of water, mineral matter, fat, and nitrogenous substance, were determined in certain separated parts, and in the entire bodies, of ten animals—namely, 1 calf, 2 oxen, 1 lamb, 4 sheep, and 2 pigs. Complete analyses of the ashes, respectively of the entire carcasses, of the mixed internal and other "offal" parts, and of the entire bodies, of each of these ten animals, have also been made.

From the data provided as above described, as to the chemical composition of the different descriptions of animal in different conditions as to age and fatness, the composition of the increase whilst fattening, and the relation of the constituents stored up in the increase to those consumed in food, have been estimated.

To ascertain the composition of the manure in relation to that of the food consumed, oxen, sheep, and pigs, have been experimented upon.

The loss or expenditure of constituents, by respiration and the cutaneous exhalations, has not been determined directly—that is, by means of a respiration apparatus, but only by difference—that is, by calculation, founded on the amounts of dry matter, ash, and nitrogen, in the food, and in the (increase) fæces and urine.

Independently of the points of inquiry above enumerated, the results obtained have supplied data for the consideration of the following questions:—

1. The sources in the food of the fat produced in the animal body. *Incidental questions.*

2. The characteristic demands of the animal body (for nitrogenous or non-nitrogenous constituents of food) in the exercise of muscular power.

3. The comparative characters of animal and vegetable foods in human dietaries.

## Food Consumed and Increase Produced.

It is proposed, first, to consider the results illustrating the amounts of food, and of its nitrogenous and non-nitrogenous constituents respectively, consumed by a given live-weight of animal within a given time, and the amounts required to produce a given amount of increase in live-weight. The illustrations will be drawn from experiments with sheep and with pigs.

### *The Experiments with Sheep.*

*Quantity of food and increase in sheep.*

Table 67 (p. 266) shows, for each of three series of experiments with sheep, in the first three columns the amounts of nitrogenous, of non-nitrogenous, and of total organic substance, *consumed per* 100 *lb. live-weight per week*, and in the last three columns the amounts *consumed to produce* 100 *lb. increase in live-weight.* The figures represent the quantities of the crude constituents consumed—that is, the amounts of nitrogenous substance calculated by multiplying the nitrogen by 6.3, which implies that the whole of it exists in the foods as albuminoids, which admittedly is not the case. It will be seen, however, that this method is quite sufficient for the purposes of the illustrations at present in view, though it is frequently far from accurate in the case of unripened vegetable products; and it is especially so in that of succulent foods, such as feeding roots. The amounts of crude non-nitrogenous substance are calculated by deducting those of the mineral matter, and of the crude nitrogenous constituents, from those of the total dry matter consumed. Here again, it is admitted that the results are only approximations to the truth; but it will be seen that, as in the case of the nitrogenous constituents, they are nevertheless quite sufficient for the purposes of our present illustrations. The crude total organic matter is simply the sum of the nitrogenous and non-nitrogenous calculated as above. *Table 67 explained.*

Referring to the results, it is impossible to go into any detail here. A glance at the figures in the first three columns of the Table (67) relating to the amounts of the constituents *consumed per* 100 *lb. live-weight per week* is sufficient to show *Explanation of results.*

that, in all comparable cases, there was much more uniformity in the amounts of the non-nitrogenous than in those of the nitrogenous substance consumed for a given live-weight of the fattening animal within a given time. The deviations from this general regularity in the amount of non-nitrogenous substance consumed are, indeed, in most cases such that, when they are examined, they tend clearly to show that the uniformity would be considerably greater if the amounts of only the really available respiratory and fat-forming constituents had been represented, instead of those of the crude or total non-nitrogenous substance consumed.

TABLE 67.—EXPERIMENTS WITH SHEEP MADE AT ROTHAMSTED IN 1850. NITROGENOUS AND NON-NITROGENOUS CONSTITUENTS CONSUMED PER 100 LB. LIVE-WEIGHT PER WEEK; AND TO PRODUCE 100 LB. INCREASE IN LIVE-WEIGHT.

| Pens. | Limited food. | *Ad libitum* food. | Per 100 lb. live-weight per week. Nitrogenous. | Per 100 lb. live-weight per week. Non-nitrogenous. | Per 100 lb. live-weight per week. Total organic. | To produce 100 lb. increase in live-weight. Nitrogenous. | To produce 100 lb. increase in live-weight. Non-nitrogenous. | To produce 100 lb. increase in live-weight. Total organic. |
|---|---|---|---|---|---|---|---|---|
| | **SERIES 1. 5 SHEEP IN EACH PEN (14 WEEKS).** | | | | | | | |
| 1 | Linseed-cake | Swedish turnips | 2.46 | 9.85 | 12.31 | 167 | 650 | 817 |
| 2 | Oats | Swedish turnips | 1.57 | 11.36 | 12.93 | 103 | 684 | 787 |
| 3 | Clover-chaff | Swedish turnips | 1.64 | 13.12 | 14.76 | 102 | 736 | 838 |
| 4 | Oat-straw chaff | Swedish turnips | 1.07 | 10.17 | 11.24 | 102 | 913 | 1015 |
| | Mean | | 1.68 | 11.13 | 12.81 | 118 | 746 | 864 |
| | **SERIES 2. 5 SHEEP IN EACH PEN (19 WEEKS).** | | | | | | | |
| 1 | Linseed-cake | Clover-chaff | 3.78 | 12.93 | 16.71 | 321 | 1103 | 1424 |
| 2 | Linseed | Clover-chaff | 3.21 | 12.66 | 15.87 | 289 | 1144 | 1433 |
| 3 | Barley | Clover-chaff | 2.58 | 13.79 | 16.37 | 235 | 1269 | 1504 |
| 4 | Malt | Clover-chaff | 2.52 | 14.02 | 16.55 | 266 | 1457 | 1723 |
| | Mean | | 3.02 | 13.35 | 16.38 | 278 | 1244 | 1521 |
| | **SERIES 3. 5[1] SHEEP IN EACH PEN (10 WEEKS).** | | | | | | | |
| 1 | Barley | Mangels | 1.70 | 10.59 | 12.29 | 118 | 731 | 850 |
| 2 | Malt and malt dust | Mangels | 1.64 | 10.12 | 11.76 | 111 | 677 | 788 |
| 3 | Barley (steeped) | Mangels | 2.08 | 12.60 | 14.68 | 121 | 730 | 851 |
| 4 | Malt and dust (steeped) | Mangels | 1.77 | 10.70 | 12.47 | 136 | 821 | 958 |
| 5 | Malt and dust (extra quantity) | Mangels | 1.89 | 11.63 | 13.52 | 126 | 776 | 903 |
| | Mean | | 1.82 | 11.13 | 12.94 | 123 | 747 | 870 |

[1] Only four sheep in pens 1, 3, and 4.

As pointed out in our earlier papers, in reading the figures allowance has obviously to be made, both for those of the non-nitrogenous constituents which would probably become at once effete, and also for the different respiratory and fat-forming capacities of the portions which are digestible. Thus, comparing series with series, the amounts are higher in Series II. where the *ad libitum* food was clover-chaff containing a large amount of indigestible fibre, than in either of the other series where it consisted of Swedish turnips or mangel-wurzel. Then, the quantity consumed was higher in the third pen of Series I., with clover-chaff, than in the other pens of the same series; and it was lower in pen 1 of Series I. with linseed-cake containing much oil, and it was again lower in pens 1 and 2 of Series II., also with much fatty matter in the food, than in the other pens of the same series with cereal grain.

Indeed, when we bear in mind the various circumstances which must tend to modify the indications of the actual figures, it will be admitted that the coincidences in the amounts of available respiratory and fat-forming constituents consumed by a given weight of animal within a given time, are much more striking and conclusive than, considering the views prevalent on the subject at the time, could have been anticipated.

With this general uniformity in the amounts of the *non*-nitrogenous substance consumed by a given live-weight within a given time, the amounts of the nitrogenous constituents so consumed are, on the other hand, seen to vary under the same circumstances in the proportion of from one to two, or three, or more.

Let us now refer to the last three columns of Table 67, which show the amounts of the respective constituents *consumed to produce* 100 *lb. increase in live-weight*. In considering these results we must, as when discussing those relating to the consumption by a given live-weight within a given time, read the indications of the actual figures as modified by the obviously different capacities for the purposes of the animal economy, of the substances the amounts of which they are assumed to represent. It must also be borne in mind, that the proportion of real dry substance in the increase of the animal will vary to some extent, according to the character of the food. For example, it will be rather the less, the more succulent the food, and the greater, the greater the proportion of fat in the increase. Again, as in the case of the results showing the consumption for a given live-weight of the fattening animal within a given time, the figures represented the demand—not only for respiration, and for maintenance in other respects, but also that for increase in live-weight, so

*Food demands for maintenance and increase in weight.*

now those specially arranged to show the relation of consumption to increase, at the same time include the amounts required by the exigencies of respiration and maintenance.

*General view of results.* Taking a general view of the results, which is all that can be done here, it is seen that where clover-chaff, with its large amount of indigestible woody-fibre, was used as the *ad libitum* food, the total amount of non-nitrogenous substance consumed to produce a given increase in live-weight was much greater than where the *ad libitum* food consisted of roots. Due allowance must, therefore, be made for this in comparing the results of one series with those of another. Doing this, it is obvious that the amounts of really available non-nitrogenous substances consumed were, at any rate much more nearly uniform in the different series, and in the different pens, than were those of the nitrogenous substance. Of the differences that would still remain, most would be again reduced by making allowance for the different respiratory and fat-forming capacities of the remaining available non-nitrogenous constituents; since, for example, much less of fatty matter would be required than of starch or sugar, or of the pectine compounds of the roots.

Again, as in the case of the consumption by a given live-weight within a given time, so now in that of the consumption to produce a given amount of increase, there is a much wider range of difference in the amounts of the nitrogenous than of the non-nitrogenous constituents consumed; and the differences are, as before, much greater than can be explained by the differences in the character of the nitrogenous substances which the figures represent in the different cases.

*Former conclusions confirmed.* Thus, then, the results of these experiments with sheep, when interpreted with due regard to the known differences in the character of the nitrogenous and non-nitrogenous constituents in the different foods, fully justify the conclusions drawn from them more than forty years ago—namely, that taking food-stuffs as they go, it is their supply of the digestible non-nitrogenous, that is of the more specially respiratory and fat-forming constituents, rather than that of the nitrogenous or specially flesh-forming ones, that regulates, both the amount of food consumed by a given live-weight of animal within a given time, and the amount of increase in live-weight produced. *Fat-formers the regulating factors.*

But, as it seems to have been tacitly assumed in recent years, since much attention has been paid to the investigation of the digestibility of the different constituents of foods, that conclusions founded on the determined amount in the foods of the crude substances only cannot be relied upon, we have had the whole of our early results, both with sheep and with

pigs, re-calculated, making correction, as far as practicable, for the amounts of the constituents in the different foods which are assumed to be indigestible, or otherwise not of food-value, according to the tables given by Emil von Wolff in the edition of his work published in 1888. He there gives for nearly 200 different articles of stock foods—the percentages of water, mineral matter (ash), crude protein, crude fibre, non-nitrogenous extractive matters, and crude fat; and then the percentages of digestible albuminoids, digestible carbohydrates, and digestible fat. In applying his data to our results, the amount of the crude substance in each description of food is reduced in the proportion which his figures show of crude to digestible in the same description of food. Further, in the case of the so estimated amounts of digestible fatty matter, the figure obtained has been multiplied by 2.4 to bring it approximately to its equivalent of carbohydrate, the amount then being added to the other digestible non-nitrogenous substance, so reckoning the whole as carbohydrate. Lastly, as Wolff makes no correction for the non-albuminoid condition of a large portion of the nitrogen in succulent roots, it has been assumed, in accordance with results obtained at Rothamsted and elsewhere, that in Swedish turnips only 45 per cent, and in mangels only 40 per cent, of the total nitrogen will exist as albuminoids. *Re-calculation according to Wolff's tables.*

There are obvious objections to some of the modes adopted for the determination of the digestible constituents of the various foods, which render them inapplicable without considerable reservation, to the estimate of the amounts of the constituents which will probably be actually digested in the case of ordinary liberal rations. But, if accepted as approximations only, they undoubtedly afford useful data for some general conclusions.

Neither space nor time will permit of either the record or the discussion of the re-calculated tables. It must suffice here to say that the results as so re-calculated, that is making correction as far as present knowledge permits, for the probable amounts of the indigestible or non-available constituents of the various foods, not only fully confirm the conclusions drawn on a careful study of the circumstances of the experiments, and of their results, more than forty years ago, but they bring out the points then maintained still more clearly to view. *Re-calculation confirming former opinions.*

*The Experiments with Pigs.*

Let us next see whether experiments with pigs lead to similar conclusions. The pig requires much less bulk in his food than the ruminant. His food, and especially his fatten- *Feeding experiments with pigs.*

ing food, consists, weight for weight, of a much larger proportion of digestible or convertible constituents, and contains very little effete woody fibre. Thus, whilst the food of oxen and sheep is composed principally of grass, hay, straw, and roots, with a comparatively small proportion of grain, leguminous seeds, or other concentrated foods, that of the pig consists largely of grain or other seeds, which contain a comparatively small amount of indigestible woody fibre, and a large proportion of starch or other digestible carbohydrate, and nitrogenous matters which are almost entirely in the condition of albuminoids. It is true that the pig consumes also more or less of starchy tubers, or saccharine roots, which contain a considerable proportion of their nitrogen in other forms than albuminoids. But the more rapidly he is fattened, the larger is the proportion in his food of starchy grains, or other ripened seeds.

*Increase in weight in cattle, sheep, and pigs.*

Notwithstanding the much more concentrated and digestible character of the food of the fattening pig, he consumes a much larger quantity of dry substance in proportion to his weight than either the ox or the sheep. Under these circumstances he yields much more increase, both in proportion to a given live-weight within a given time, and to a given amount of dry substance of food consumed. This is clearly illustrated in Table 69, p. 287, which shows, as an approximate average, that per 100 lb. live-weight per week, the fattening ox will consume about 12.5 lb. of dry substance of food, and yield about 1.13 lb. of increase; the sheep will consume about 16 lb. of dry substance of food, and yield about 1.76 lb. of increase; whilst the pig, on the other hand, will consume about 27 lb. of dry substance of his more concentrated food, and yield about 6.43 lb. of increase. Indeed, compared with oxen or sheep, the liberally fed fattening pig will consume much more food in excess of that required for the respiratory function and for mere maintenance, so that the amounts of non-nitrogenous matters consumed for a given live-weight within a given time represent in less proportion the respiratory requirements, and in a greater proportion those for increase.

*Plan of pig experiments.*

Numerous feeding experiments have been made at Rothamsted with pigs. In 1850, Series 1, with twelve pens, Series 2, also comprising twelve pens, and Series 3, with five pens, and subsequently a fourth Series of four pens, was made. The general plan was to give, in one or more pens, food of high or of low percentage of nitrogen as the case might be, *ad libitum;* then in others to give a fixed and limited amount of food of low percentage of nitrogen, and *ad libitum* a food of high percentage; or a fixed and limited amount of food of high percentage of nitrogen, and *ad libitum* a food of low

percentage, and so on; and as the *ad libitum* food always supplied much the larger proportion of the total ration, the animals fixed their own consumption, according to the composition of the foods, and to their own requirements, including those both for respiration and maintenance, and for increase.

The foods of high percentage of nitrogen consisted in most cases of an equal mixture of bean and lentil meal—that is, of highly nitrogenous leguminous seeds—and those of low percentage were, in most cases, either maize-meal or barley-meal. In some, however, either pure starch or pure sugar was given. The details of the foods, the weights and increase of the animals, and of the amounts of the various foods, and of their nitrogenous and non-nitrogenous constituents consumed, per 100 lb. live-weight per week, and to produce 100 lb. of increase in live-weight, have been given and fully discussed in various papers.[1] *Foods tried.*

The conclusion drawn from the results of the various experiments with pigs was that in their case, as in that with sheep, it was the supplies in the food of the available non-nitrogenous, or total organic constituents, rather than those of the available nitrogenous substance, that regulated the amount consumed, both by a given live-weight within a given time, and to produce a given amount of increase. The point is, however, even more clearly brought to view by the graphic representation of the results given in the coloured diagrams following p. 354. *Conclusions drawn from pig trials.* *Coloured diagrams.*

In explanation of them it may be stated, that nitrogenous substance is represented by black, non-nitrogenous by yellow, and total organic substance by red. Diagram I. illustrates the relative amounts of the respective constituents consumed per 100 lb. live-weight per week, and Diagram II. the amounts consumed to produce 100 lb. increase in live-weight. Each of the thirty columns represents the results of a separate experiment or pen.

The first nine columns show the results of experiments 1-8, and 12, of Series 1; the next twelve those of the twelve experiments of Series 2; the next five those of the five experiments of Series 3; and the last four those of the four experiments of Series 4. It may be added that there were three pigs in each pen of Series 1, 2, and 4, and four in each pen of Series 3.

The plan of the diagrams in other respects will be best understood by giving an example. Take, for instance, the

[1] "On the Composition of Foods in relation to Respiration and the Feeding of Animals" (*Rep. Brit. Ass.* for 1852). "Pig-Feeding" (*Jour. Roy. Ag. Soc. Eng.*, vol. xiv. p. 459, 1853).

amounts of nitrogenous substance consumed per 100 lb. live-weight per week, as represented in black, in the left-hand division of Diagram I. The lowest amount so consumed throughout the thirty experiments was in pen 5—and that amount is taken as 100, and as the standard by which to compare the amounts consumed in the other pens—and it will be seen that, in the case of this pen 5, the colouring does not extend above the base-line, which is numbered 100 in the column of figures given at each side of the diagram. It will be further seen that the figures range up to 300, and that, for example, in the case of pen 1 the black colouring extends above the 300 line. That is to say, there were more than 300 parts of nitrogenous substance consumed in that pen, against only 100 in pen 5. In like manner, the height of the colouring for each of the other pens represents the proportion of nitrogenous substance consumed in that pen compared with the amount in pen 5 taken as 100.

Exactly the same plan is adopted in representing the relative amounts of non-nitrogenous and of total organic substance consumed in the different pens. Thus the lowest amount of non-nitrogenous substance consumed per 100 lb. live-weight per week was in pen 10, which is therefore represented as 100, and the relative amounts consumed in the other pens are represented by the different heights of the yellow colouring above the 100 base-line.

Again, of total organic substance consumed per 100 lb. live-weight per week, the lowest amount was in pen 23, and the greater amount so consumed in each of the other pens is represented by the height above the base-line of the red colouring in each case.

It need only be added that precisely the same plan is followed in the construction of Diagram II., which shows the relative amounts of the substances consumed in the different experiments to produce 100 lb. increase in live-weight.

*Difference in results from nitrogenous and non-nitrogenous constituents.*

Referring to the results, and first to those represented in Diagram I., which shows the relative amounts consumed per 100 lb. live-weight per week, a glance brings strikingly to view the fact, that there was no uniformity whatever in the amounts of nitrogenous substance so consumed in the thirty different cases, representing as many different rations. Indeed, it is seen that the amounts ranged in the proportion of 100 to more than 300; with very great variation between these amounts. The range in the non-nitrogenous substance so consumed is, on the other hand, very much less; reaching in but few cases from 100 to 150. Lastly, in the case of the total organic substance the range is less still.

Next referring to Diagram II., showing the relative amounts of the different constituents consumed to produce 100 lb. increase in live-weight, there is again no uniformity in the amounts of nitrogenous substance so consumed. There is, however, great uniformity in the amounts of the non-nitrogenous substance consumed; and there is, in the majority of cases, about the same uniformity in those of the total organic substance consumed.

It should be understood that, in these diagrams relating to pigs, as in the table relating to the experiments with sheep, it is the amounts of the crude nitrogenous, the crude non-nitrogenous, and the crude total organic substance, as determined by the methods of analysis already described, and which were the only ones practicable at the time, that are represented. Of course, therefore, the indications of the actual results have, as in the case of those with sheep, to be interpreted with due regard to the known facts in each case. But, to meet objection, we nearly twenty years ago re-calculated the results, and re-constructed the diagrams, making correction for indigestible or non-available constituents in the various foods, in accordance with the then published tables of Professor Emil von Wolff; and more recently, as in the case of the experiments with sheep, we have had them again re-calculated according to his subsequently revised tables, already referred to.

*Re-calculation of results.*

It may be stated that the diagrams, as first re-constructed, entirely confirmed the conclusions previously drawn; and indeed illustrated the points brought out by those at first, and now again given, even more strikingly still. That is, they showed a wider range in the amounts of the nitrogeous substance consumed in the different experiments; with one or two easily explained exceptions, a less variation in the amounts of the non-nitrogenous substance; and especially a less range in the amounts of total organic substance consumed. The two methods showed, moreover, with some obviously necessary exceptions, comparatively little difference in what is called the "*nutritive ratio*," that is, the relation of the non-nitrogenous to the nitrogenous constituents. As it is impossible on this occasion to give and discuss both sets of results, it seems best, after this explanation, to adhere to the originally obtained and recorded results which led to the conclusions arrived at so long ago, rather than to adopt corrections based upon factors as yet not sufficiently established. Nevertheless, it is satisfactory to find that, applying the best methods of correction which subsequent investigations suggest, the conclusions formerly drawn are confirmed and emphasised, rather than in any way vitiated or modified.

*Former conclusions confirmed.*

*Established conclusions.*

*Nitrogenous and non-nitrogenous substances as substitutes for each other.*

In conclusion in regard to this branch of the subject:—it must be considered established, that, taking ordinary food-stuffs as they go, neither the amount consumed in relation to a given live-weight of the animal within a given time (which of course in the fattening animal covers the requirements for increase as well as for sustenance), nor the amount consumed to yield a given amount of increase in live-weight (which covers the requirements for sustenance also), was at all in proportion to the amount of the nitrogenous constituents supplied. It is, on the other hand, obvious that the consumption, both for sustenance and for increase, was much more nearly in proportion to the amount of the digestible and available non-nitrogenous constituents supplied; but, that it was more nearly still regulated by the amount of the total digestible organic substance—nitrogenous and non-nitrogenous together—which the foods supplied. The indication is, indeed, as will be more clearly seen further on, that, if there be a deficiency of available non-nitrogenous constituents, an excess of the nitrogenous may to a certain extent take the place of the non-nitrogenous; that, in fact, within certain limits, the two classes of constituents may, for the purposes of respiration and fat-formation, mutually replace each other.

*Respiratory products and respiratory function.*

When the character of the main products of respiration, and the prominence, in a quantitative sense, of the respiratory function in the maintenance of the body, are considered, it seems only what might be expected, that the consumption by a given live-weight of animal within a given time should be regulated, more by the supplies in the food of the oxidable non-nitrogenous, than of the nitrogenous or more specially flesh-forming constituents; and now that it is known, as will further on be shown is the case, that in the exercise of force the respiratory action is enormously increased, whilst that of nitrogenous transformation is but little augmented, the result is rendered still more consistent and intelligible.

That the increase in live-weight of the animal should (provided the food be not abnormally poor in nitrogenous substances) also be regulated more by the supplies of the non-nitrogenous than of the nitrogenous or flesh-forming constituents, does not at first sight seem so intelligible.

*Relative value of nitrogenous and non-nitrogenous substances as food and manure.*

There is, however, no doubt of the fact, that our current fattening rations are, *as such*, more valuable in proportion to their richness in digestible and available non-nitrogenous, than to that of their nitrogenous constituents. At the same time, as the manure is valuable largely in proportion to the nitrogen it contains, there is, so far, an advantage in giving a food rich in nitrogen, provided it is in other respects a good

one, and, weight for weight, not much more costly. But, since in recent years the vegetable products most benefited by nitrogenous manures have been so largely imported as much to reduce the value of the home-grown crops, even this advantage of highly nitrogenous food-stuffs is becoming of less importance, and that of having the best food for the progress of the animal one of more and more consideration.

The question obviously suggests itself, of what does the increase of the animal chiefly consist? To experimental evidence on this point attention will next be directed.

## Composition of Oxen, Sheep, and Pigs, and of their Increase whilst Fattening.

It is proposed to show the composition of some of the animals of the farm, in different conditions as to age and fatness; to estimate the probable composition of their increase in live-weight during the fattening process; and to show the relation of the constituents in the increase to those consumed in the food. The results which have been obtained will also afford data for the discussion of the question of the sources in the food of the fat produced in the animal body; they will further supply evidence as to the composition of the manure in relation to that of the food consumed; and lastly, they will lead to a consideration of the characteristic food-requirements of the body in the exercise of force.

*Animals experimented upon.* To determine the ultimate composition, and in a sense the proximate composition also, of oxen, sheep, and pigs, and under such conditions that the results obtained should serve as data for the estimation of the probable composition of their increase whilst growing and fattening, ten animals were selected for analysis—namely, a fat calf, a half-fat ox, and a fat ox; a fat lamb, a store sheep, a half-fat old sheep, a fat sheep, and an extra-fat sheep; a store pig, and a fat pig.

*Table 68 explained.* Table 68 (p. 276) shows the percentage of mineral matter, of nitrogenous compounds, of fat, of total dry substance, and of water—in the upper division in the collective carcass parts, in the middle division in the collective offal parts (excluding contents of stomachs and intestines), and in the lower division in the entire bodies of the ten animals; the weight of the contents of stomachs and intestines being also given.

*Relation of the mineral matter and the nitrogenous constituents of the body.* It may in the first place be observed that, comparing one animal with another, all the results tend to show a prominent connection between the amount of total mineral matter and that of the nitrogenous constituents of the body; there being a general tendency to a rise or fall in the percentage of

TABLE 68.—PERCENTAGE COMPOSITION OF THE CARCASSES, THE OFFAL, AND THE ENTIRE BODIES, OF TEN ANIMALS, OF DIFFERENT DESCRIPTIONS, OR IN DIFFERENT CONDITIONS OF MATURITY.

| Description of animal. | Mineral matter (ash). | Nitrogenous substance | Fat. | Total dry substance. | Water. | Contents of stomachs and intestines (in moist state). |
|---|---|---|---|---|---|---|
| **PER CENT IN CARCASS.** | | | | | | |
| Fat calf | 4.48 | 16.6 | 16.6 | 37.7 | 62.3 | |
| Half-fat ox | 5.56 | 17.8 | 22.6 | 46.0 | 54.0 | |
| Fat ox | 4.56 | 15.0 | 34.8 | 54.4 | 45.6 | |
| Fat lamb | 3.63 | 10.9 | 36.9 | 51.4 | 48.6 | |
| Store sheep | 4.36 | 14.5 | 23.8 | 42.7 | 57.3 | |
| Half-fat old sheep | 4.13 | 14.9 | 31.3 | 50.3 | 49.7 | |
| Fat sheep | 3.45 | 11.5 | 45.4 | 60.3 | 39.7 | |
| Extra-fat sheep | 2.77 | 9.1 | 55.1 | 67.0 | 33.0 | |
| Store pig | 2.57 | 14.0 | 28.1 | 44.7 | 55.3 | |
| Fat pig | 1.40 | 10.5 | 49.5 | 61.4 | 38.6 | |
| Means of all | 3.69 | 13.5 | 34.4 | 51.6 | 48.4 | |
| **PER CENT IN OFFAL (EX-CONTENTS OF STOMACHS AND INTESTINES).** | | | | | | |
| Fat calf | 3.41 | 17.1 | 14.6 | 35.1 | 64.9 | |
| Half-fat ox | 4.05 | 20.6 | 15.7 | 40.4 | 59.6 | |
| Fat ox | 3.40 | 17.5 | 26.3 | 47.2 | 52.8 | |
| Fat lamb | 2.45 | 18.9 | 20.1 | 41.5 | 58.5 | |
| Store sheep | 2.19 | 18.0 | 16.1 | 36.3 | 63.7 | |
| Half-fat old sheep | 2.72 | 17.7 | 18.5 | 38.9 | 61.1 | |
| Fat sheep | 2.32 | 16.1 | 26.4 | 44.8 | 55.2 | |
| Extra-fat sheep | 3.64 | 16.8 | 34.5 | 54.9 | 45.1 | |
| Store pig | 3.07 | 14.0 | 15.0 | 32.1 | 67.9 | |
| Fat pig | 2.97 | 14.8 | 22.8 | 40.6 | 59.4 | |
| Means of all | 3.02 | 17.2 | 21.0 | 41.2 | 58.8 | |
| **PER CENT IN THE ENTIRE ANIMAL (FASTED LIVE-WEIGHT).** | | | | | | |
| Fat calf | 3.80 | 15.2 | 14.8 | 33.8 | 63.0 | 3.17 |
| Half-fat ox | 4.66 | 16.6 | 19.1 | 40.3 | 51.5 | 8.19 |
| Fat ox | 3.92 | 14.5 | 30.1 | 48.5 | 45.5 | 5.98 |
| Fat lamb | 2.94 | 12.3 | 28.5 | 43.7 | 47.8 | 8.54 |
| Store sheep | 3.16 | 14.8 | 18.7 | 36.7 | 57.3 | 6.00 |
| Half-fat old sheep | 3.17 | 14.0 | 23.5 | 40.7 | 50.2 | 9.05 |
| Fat sheep | 2.81 | 12.2 | 35.6 | 50.6 | 43.4 | 6.02 |
| Extra-fat sheep | 2.90 | 10.9 | 45.8 | 59.6 | 35.2 | 5.18 |
| Store pig | 2.67 | 13.7 | 23.3 | 39.7 | 55.1 | 5.22 |
| Fat pig | 1.65 | 10.9 | 42.2 | 54.7 | 41.3 | 3.97 |
| Means of all | 3.17 | 13.5 | 28.2 | 44.9 | 49.0 | 6.13 |

mineral matter, with the rise or fall in that of the nitrogenous compounds.

*Composition of carcasses.* Comparing the composition of the different carcasses, it is seen that there was, in every instance excepting that of the calf, a considerably higher percentage of fat than of total nitrogenous substance.

In the carcass of even the store or lean sheep, there was more than one and a half time as much fat as nitrogenous substance; and in that of the store or lean pig there was twice as much. In the carcass of the half-fat ox there was one-fourth more fat than nitrogenus matter; and in that of the half-fat old sheep there was more than twice as much.

Of the fatter animals, those assumed to be in a suitable condition for sale as human food, the carcass of the fat ox contained twice and one-third as much, that of the fat sheep four times, and that of the very fat sheep even six times, as much fat as nitrogenous substance. Lastly, in the carcass of the moderately fat pig, there was nearly five times as much fat as nitrogenous compounds.

*Composition of offal.* Turning now to the second division of the Table (68), which shows the composition of the collective offal parts (excluding contents of stomachs and intestines), the figures do not show such a uniform tendency to a diminution in the percentage of mineral matter coincidently with that of the nitrogenous substance as the animal matures, as was observed in the case of the carcasses. This, however, is doubtless due to the fact that the ash of the offal parts includes adventitious matter adhering to the pelt, hair, or wool, which it was impossible entirely to remove.

It is seen that the percentage of nitrogenous substance is in every case but one greater, and that of the fat very much less, in the collective offal than in the collective carcass parts. In the case of oxen and sheep, a large amount of the nitrogenous substance of the offal is in the non-consumable portions—the pelt, hair or wool, and hoofs; whilst some of the remainder is in the stomachs and intestines, which are only very partially consumed, and the rest in other parts which are more generally consumed, namely, the head flesh, with tongue and brains, the heart, the liver, the pancreas, the spleen, the diaphragm, and sometimes the lungs.

Lastly in regard to the composition of the collective offal parts, it is seen that they contain a higher percentage of nitrogenous substance, a lower percentage of fat, and a lower percentage of total dry substance, and consequently a larger proportion of water, than the collective carcass parts.

It is obviously a matter of interest, both from a dietetic point of view, and as showing what proportion of the gross

*Proportion of animal substance consumed as food.*

product of the feeding process is saleable as human food, to consider what proportion of the fat, and of the nitrogenous substance of the slaughtered animals will, on the average, be consumed as human food in one form or another. The result of much inquiry leads to the conclusion that, in our own country, on the average, the whole of the carcass fat, and about one-fifth of the offal fat, of oxen will be consumed; that of sheep, an amount equal to the whole of their carcass fat will be consumed; and that of the pig, an amount equal to the whole of its carcass fat, and, in addition, more or less of its offal fat, will be sold and consumed as food.

Calculation leads to the conclusion, that about one-sixth of the whole of the nitrogenous matter of the collective offal parts of oxen will, on the average, be consumed, but that the whole of the nitrogenous matter reclaimed as food from the offal parts will fall short of the amount contained in the bones of the carcass. So nearly, however, will these quantities balance one another, especially if a portion of the gelatine from the carcass-bones be consumed, that it may be assumed that, of the total nitrogenous substance of the bodies of these animals. only about as much as, or very little more than, is represented by the total amount in the carcasses, will be consumed. In the case of pigs, however, a larger proportion of the total nitrogenous substance of the body will be consumed than in that of the other animals; but, as the table shows, the percentage of total nitrogenous substance is less, and that of the fat much greater, in the pig than in the other animals.

Upon the whole, therefore, it would seem that the proportion of the consumed fat to the consumed nitrogenous substance will, on the average, be greater than its proportion in the total carcasses of the fattened animals. Such is pretty certainly the case in our own country; but the relations are admittedly far otherwise in the United States, and it is, to say the least, very questionable whether the difference is to the advantage of the consumers in that country.

*Composition of the entire animal.*

Let us now turn to the lower division of the Table (68), showing the composition of the entire bodies of the animals, which, of course, represents the gross product of the feeding process. It is this, therefore, that is of most interest to the farmer to consider in connection with the composition of the food expended in its production.

As was the case in the carcasses, there is also in the entire bodies a marked diminution in the percentage of mineral matter as the animal matures. Judging from the results of the analyses of the ashes of the animal bodies, it may be stated in general terms that about, or rather more than, 40

per cent of the total mineral matter of the animals is phosphoric acid. In the case of oxen and sheep, nearly 45 per cent, and in that of pigs about 40 per cent, will be lime; whilst of potash, the ash of oxen and sheep will probably contain from 5 to 6 per cent, and that of pigs 7 to 8 per cent, or more.

Of total nitrogenous compounds, as well as of total mineral matter, oxen seem to contain, in parallel conditions, a rather higher percentage than sheep, and sheep rather more than pigs. It is seen that the entire body of the fat calf contained about 15¼, that of a moderately fat ox 14½, of a fat lamb 12⅓, of a fat sheep 12¼, of a very fat one about 11, and of a moderately fattened pig also about 11 per cent of nitrogenous substance. The store or lean animals contained from 2 to 3 per cent more than the moderately fat ones.

The figures show, on the other hand, that fat constitutes by far the largest item in the dry or solid matter of the entire bodies of the animals, especially of those fit for slaughtering as human food. Even the half-fat ox contained about 19 per cent of fat, or more than of nitrogenous substance. The entire body of the store sheep also contained nearly 19 per cent of fat, that is, several per cent more than of nitrogenous substance; that of the half-fat old sheep 23½ per cent, or more than 1½ time as much as of nitrogenous substance; and that of the store pig also more than 23 per cent of fat, and about 1⅔ time as much as of nitrogenous substance.

Of the fattened animals, the entire body of the fat ox contained rather more, and that of the fat lamb rather less, than 30 per cent of fat; that of the fat sheep 35½ per cent, of the very fat sheep 45¾ per cent, and that of the fat pig about 42 per cent of fat. The fat calf, however, contained even rather less than 15 per cent of fat.

Thus, the entire bodies, even of store or lean animals, may contain more fat than nitrogenous compounds, whilst those of fattened animals may contain several times as much. That of the fat ox contained more than twice as much, that of the moderately fat sheep nearly three times, of the very fat sheep more than four times, and of the moderately fattened pig about four times, as much fat as nitrogenous substance.

*Change in the composition of the animal in process of fattening.*

In conclusion on this point—all the experimental evidence concurs in showing, that the so-called *fattening* of animals is properly so designated. During the feeding or fattening process, the percentage of the total dry substance of the body is considerably increased; and the fatty matter accumulates in much larger proportion than the nitrogenous substance. It is obvious, therefore, that the *increase* of the fattening animal must contain a lower percentage of nitrogenous substance, and

a higher percentage of both fat and total dry substance, than the entire body of the animal.

It is obvious, however, that the results of the analyses of the ten animals do not supply data directly applicable for the estimation of the composition of animals in the very various conditions in which they are dealt with in practice, or of their increase over any given period under varying conditions of feeding. Accordingly, we have constructed tables founded on the analytical results above referred to, showing the probable average percentage composition of the different descriptions of animal, each at eight gradationary points from the store to the very fat condition; and the factors thus obtained have been applied for the calculation of the composition of the increase in a number of cases of ordinary practice, or of direct experiment in which the weights of the animals at the commencement and at the conclusion of a fixed period, the general character of the food they consumed, and their final condition, were more or less fully known. It is admitted that these eight conditions do not cover all the variations of composition occurring in actual practice; but at the same time there can be no doubt that by the aid of such factors the feeder would be enabled to calculate, with sufficient approximation to the truth for all practical purposes, the composition of the store animals he buys or sells, and of the fat ones he sells. At any rate, we believe that the results are the best that existing knowledge enables us to provide.

*Construction of the tables, showing average composition of animals.*

It is impossible to go into any detail here, either as to the composition of the animals at the different stages, or as to the estimated composition of their increase, but the results may be briefly summarised as follows:—

*Composition of animals at different stages of feeding.*

In the case of oxen, the figures representing the composition of the animals at different stages of progress show—that the percentage of mineral matter ranged from 5.15 in the store to only 3.43 in the very fat condition; that of the nitrogenous substance from 18.0 in the store to only 13.1 in the very fat state; and that of the fat increased from 11.7 in the store to 37.4 in the very fat condition. Again, the percentage of total dry substance increases from only 34.8 in the store to 54.0 in the very fat condition. Lastly, the percentage of water decreases from the store to the very fat condition.

The parallel results for sheep show that the percentage of mineral matter ranges from 3.25 in the store to only 2.90 in the very fat animal; the nitrogenous compounds from 15.5 per cent in the store to only 10.9 per cent in the very fat condition; and against these reductions the fat increases from 14.5 per cent in the store to 45.8 per cent in the very fat condition; and the total dry substance from 33.2 per cent to

59.6 per cent. There is, therefore, a lower percentage of total dry substance in the store sheep than in the store ox, owing to the less amount of mineral and nitrogenous matter in the store sheep. There is, on the other hand, a higher percentage of dry substance in the very fat sheep than in the very fat ox, owing to the higher percentage of fat in the sheep. Lastly, in the sheep the percentage of water diminishes from the earliest to the latest stage from 60.8 to only 35.2.

The results relating to the composition of pigs showed a reduction in the percentage of mineral matter from 2.93 in the store to only 1.14 in the very fat condition; and a reduction in that of nitrogenous substance from 14.4 in the store to 9.5 in the very fat state. But, instead of a reduction, there is an increase in the percentage of fat from 18.6 in the store to 51.6, or to more than half the weight of the body, in the very fat condition; and there is an increase in the percentage of total dry substance from 35.9 in the store to 62.2 in the very fat condition; and (excluding contents of stomachs, &c.) a reduction in the percentage of water from 58.6 to 34.4.

It may be observed that in no case do the percentages of total dry substance and of water make up 100; the difference being represented by the contents of stomachs and intestines, the amounts of which found in the animals actually analysed are taken as the basis of the estimates for the amounts in the other conditions, just as in the case of the other constituents of the body.

*Composition of the increase in live-weight.*

Let us next summarise very briefly the results of the application of these data as to the composition of the animals in different conditions, for the purpose of estimating the composition of their increase in passing from one condition to another.

First referring to oxen, the composition of their increase during the feeding process has been estimated in the case of the recorded results of actual practical feeding, in some cases of large numbers of animals, and over considerable periods of time. Other cases have been those of results obtained at Rothamsted, or under Rothamsted superintendence, mostly in direct feeding experiments, but sometimes in the feeding of animals in the ordinary practice of the farm.

Reviewing the whole of the results, the indication was, that the composition of the *increase* of moderately fattened oxen during a final fattening period of several months will contain about, or little more than, 1½ per cent of mineral matter, seldom more than 7 to 8 per cent of nitrogenous substance and seldom as little as 60, and generally nearer 65 per cent of fat; whilst the total dry substance of the increase

Difference in growing and fattening increase.

will generally range from 70 to 75 per cent. In the case, however, of oxen fattened very young, and the feeding period extending over a much longer time, similar calculations lead to the conclusion that the growing and fattening increase of such animals may contain perhaps 2½ per cent or more of mineral matter, against only about 1½ per cent over a limited final period of more purely fattening increase; about 10 per cent of nitrogenous substance, against only 7 to 8 per cent in the only fattening increase; and perhaps only from 50 to 55 per cent of fat, against from 60 to 65 per cent in the more exclusively fattening increase. In fact, whilst the growing and fattening increase would consist of about two-thirds dry substance and one-third water, that of the more purely fattening increase would consist of nearly three-fourths dry substance and only about one-fourth water.

Similar results relating to sheep, lead to the conclusion that during a final period of some months of feeding on good fattening food, their increase will generally contain not less than 2 per cent of mineral matter, and frequently more; that is distinctly more than in the case of oxen, the quantity largely depending on the amount of wool. Of nitrogenous substance, the final fattening increase of sheep will probably seldom contain more than 7 per cent, and frequently somewhat less. In other words, notwithstanding the large amount of nitrogen in the wool of sheep, their fattening increase will probably generally contain less nitrogenous substance than that of oxen. On the other hand, the increase of well fed and moderately fattened sheep will generally contain nearly, and sometimes more than, 70 per cent of fat, against an average of less than 65 per cent in the case of oxen; and in the case of very fat sheep the percentage of fat in the increase may even reach 75 per cent.

Upon the whole, it may be assumed that the increase of liberally fed and moderately fattened sheep, over several months of final fattening, will probably consist of about 2 per cent of mineral matter, about, or less than, 7 per cent of nitrogenous substance, from 65 to 70 per cent of fat; and in all, of from 75 to 80 per cent of total dry substance; whilst the increase over the final period of excessive fattening may contain from 70 to 75 per cent of fat, and from 80 to 85 per cent of total dry substance.

Referring to pigs, the increase of those liberally and suitably fed for fresh pork will probably, on the average, contain —an immaterial amount of mineral matter, only from 6½ to 7½ per cent of nitrogenous substance, from 65 to 70 per cent of fat, and from 70 to 75 per cent of total dry substance. The increase over the last few months of high feeding of pigs fed

for curing will, however, probably contain lower percentages of nitrogenous substance, but higher, and sometimes considerably higher, percentages of both fat and total dry substance. The tendency of the demand in recent years has, however, been for less excessively fat bacon than formerly.

*Nitrogenous and non-nitrogenous substances of food in increase in live-weight.*

Thus far, then, it has been shown that the amounts of food, or of its various constituents, consumed, both for a given live-weight of animal within a given time, and to produce a given amount of increase, were very much more dependent on the quantities of the non-nitrogenous, than on those of the nitrogenous constituents, which the food supplied. It has been said, that when the large requirement for non-nitrogenous constituents of food to meet the expenditure by respiration is borne in mind, it need not excite surprise that consumption in relation to a given live-weight within a given time should be so largely measurable by the amount of digestible and available non-nitrogenous substance which the food supplies; but that, at first sight, it was less intelligible that the quantities consumed to produce a given amount of increase in live-weight should also be much more dependent on the supplies of the non-nitrogenous, than on those of the nitrogenous, constituents of the food.

*Proportion of fat and nitrogenous matter in the composition of animals.*

The results relating to the chemical composition of the different animals, in different conditions as to age and maturity, have shown, however, that even store animals may contain as much, or even more, of the non-nitrogenous substance—fat—than of nitrogenous substance; whilst the bodies of fattened animals may contain two, three, four, or even more times as much dry fat as dry nitrogenous matter. It has further been shown, that the proportion of fat to nitrogenous substance in the *increase in live-weight* of the fattening animal, is much higher than in the entire bodies of the fattened animals. If, therefore, the non-nitrogenous substance of the increase—the fat—is derived from the non-nitrogenous constituents of the food, the relatively large demand for such constituents for the production of fattening increase, would seem to be amply accounted for.

*An important question.*

The important question arises, therefore, What are the sources in the food of the fat of the fattening animal? In other words, from what constituent or constituents in the food is the fat produced?

## SOURCES IN THE FOOD OF THE FAT PRODUCED IN THE ANIMAL BODY.

*Source of fat.* Prior to the publication of Liebig's work on *Organic Chemistry in its Applications to Physiology and Pathology*, in 1842, it seems to have been assumed that the Herbivora derived their fat from ready-formed fatty matters in their food; and that the Carnivora derived theirs from the ready-formed fat of the animals they consumed. *Liebig's view.* Liebig argued that, as a rule, the food consumed by the Herbivora did not contain sufficient fatty matter for the purpose; and he maintained that, although fat might be formed from the nitrogenous substance of the food, its main source was the starch, sugar, and other carbohydrates, which the food supplied.

*Opinion of Boussingault and others.* Dumas and Boussingault[1] at first called in question the view that fat was produced in the animal body, and assumed that the food of the Herbivora supplied sufficient fatty matter to account for the whole of the fat stored up. Subsequently, however, Dumas and Milne-Edwards,[2] from the results of experiments with bees, Persoz[3] from experiments with geese, and Boussingault[4] from those with pigs, geese, and ducks, concluded that fat was formed from the carbohydrates of the food. At the same time Boussingault considered that, in normal feeding, the amount of albuminoids consumed would generally supply sufficient carbon for the production of the fat formed by the animal.

*Rothamsted experiments.* Next came the evidence of the Rothamsted experiments, the majority of which were conducted within the years 1848-1853 inclusive; and they involved feeding experiments on between 400 and 500 animals, with foods of known composition; the slaughter, determination of the weights of the parts, and noting on the character as to fatness, &c., of more than 300 animals; and finally, the chemical analysis of ten animals.

*Fat in animals and in food.* In the first place, it was clearly demonstrated that much more fat was stored up in the bodies of the fattening animals than could be derived from the ready-formed fatty matter in their food. Secondly, from a careful study of the enormous amount of experimental data obtained, as well as of the known facts of practical experience in feeding, it was considered no doubt whatever could be entertained that much, *Fat derived from carbohydrates.* if not the whole, of the fat formed in the bodies of the herbivora fed for the production of meat was derived from the carbohydrates of the food.

[1] *Balance of Organic Nature*, 1844, p. 116 *et seq.*
[2] *Compt. Rend.*, vol. xvii. p. 531.
[3] *Ann. Chim. Phys.*, vol. xiv. p. 408 *et seq.*
[4] *Ibid.*, vol. xiv. p. 419 *et seq.;* xviii. p. 444 *et seq.*

In fact, the experimentally determined relation of the non-nitrogenous, and of the nitrogenous constituents of the food, respectively, to the amount of increase produced; the composition of fattening increase generally; the relatively greater tendency to grow in frame and to form flesh with highly nitrogenous food; the greater tendency to form fat with food comparatively rich in non-nitrogenous substances, and especially in carbohydrates; and common experience in feeding—all pointed in the same direction.

*Liebig's view supported.*

For some years there was little or no discussion on the subject, and it seemed to be tacitly admitted, both on the Continent and in this country, that the views of Liebig, as to the formation of at any rate much of the fat of the herbivora from carbohydrates, were correct.

*Views of Voit and Pettenkofer.*

In 1865, however, at a meeting of a Congress of Agricultural Chemists, held at Munich, in August of that year, Professor Voit, from the results of experiments made in Pettenkofer's respiration apparatus, with dogs fed chiefly on flesh, maintained that fat must have been produced from nitrogenous substance; and that this was probably the chief, if not the only, source of the fat even of herbivora.

Pettenkofer and Voit further maintained, that to establish the formation of fat from the carbohydrates, experiments must be brought forward in which the fat deposited was in excess of that supplied by the food, *plus* that which could be derived from the transformation of albumin.

Of course, the mere fact that the food consumed contained enough nitrogenous substance for the formation of all the fat that had been produced, would of itself be no proof that that substance had been its exclusive source. On the other hand, if the amount of fat stored up in the animal was in excess of that which could be derived from the ready-formed fatty matter of the food, and from the transformation of the nitrogenous substance, it would be proved that at any rate some of the stored-up fat must have had another source—and this could only be the carbohydrates.

Accordingly, the results of many of the Rothamsted feeding experiments were calculated, to ascertain whether or not the ready-formed fat, and the nitrogenous substance of the food, were sufficient to account for the whole of the fat estimated to have been stored up. None of the experiments had been specially arranged with a view to the elucidation of this question. In some of them, however, what may be called minimum amounts, and in others excessive quantities of nitrogenous substance, had been consumed. Some of the results seemed to us to afford clear evidence on the point, and we gave a paper on the subject in the Physiological

*Rothamsted results.*

Section, at the meeting of the British Association for the Advancement of Science, at Nottingham, in 1866; and it was published, in abstract, in the 'Report of the British Association' for 1866, and in full in the 'Philosophical Magazine' for December of that year. And, as it is upon the results as then given that any subsequent discussion of our conclusion has been founded, it is proposed, in the first place, to consider the evidence afforded by those results; but afterwards to adduce certain modifications of some of them, in order to bring them more into accord with recent knowledge on some points, and to meet more effectively objections that have been raised against the conclusions drawn from them.

The first point to consider was—What description of animal is likely to yield the most direct and conclusive results on the subject? Obviously the one which is fed more especially with the view to the production of fat; which consumes in its most appropriate fattening food a comparatively low proportion of nitrogenous substance, and a comparatively high proportion of carbohydrates; and which yields a large proportion of fat, both in relation to the weight of its body within a given time, and to the amount of food consumed. The following Table (69) briefly summarises the results of very numerous experiments with oxen, sheep, and pigs, so far as they illustrate the comparative characters of the different descriptions of animal in regard to the points above enumerated.

*Table 69 explained.*

*Fattening qualities of animals.*

In the first place it is to be observed, that although the proportion of intestines and contents is greater, that of the stomach and contents is very much less in the pig than in either of the ruminants, as also is that of the stomachs and contents, and intestines and contents, taken together; the percentage of these collectively being, in oxen 14.3, in sheep 10.9, and in pigs only 7.5 of the weight of the body. The fact is, that the appropriate fattening food of the pig consists of ripened seeds, and highly starchy roots, containing but little indigestible fibre, whilst that of the ruminants contains a considerable amount of slowly digestible or indigestible cellulose, and often a much greater amount of indigestible or unassimilable nitrogenous substance. The result is, that a less proportion of the live-weight of the pig consists of more or less effete matter retained in the alimentary organs.

Then, the second division of the table shows, that with the much higher character of its food, and the much less proportion of it indigestible and effete, the pig both consumes very much more, and yields very much more increase; for a given live-weight within a given time.

Lastly, as is shown in the third division of the table, for 100 *of dry substance of food consumed*, the pig yields very much more, both of fat and of dry substance in increase; and, on the other hand, voids very much less of dry substance in urine and in fæces.

TABLE 69.—SHOWING THE COMPARATIVE FATTENING QUALITIES OF DIFFERENT ANIMALS.

| | Oxen | Sheep. | Pigs. |
|---|---|---|---|
| RELATION OF PARTS IN 100 LIVE-WEIGHT. | | | |
| Average of . . . . . . . . | 16 | 249 | 59 |
| Stomach and contents . . . . . . | 11.5 | 7.4 | 1.3 |
| Intestines and contents . . . . . | 2.8 | 3.5 | 6.2 |
| | 14.3 | 10.9 | 7.5 |
| Internal loose fat . . . . . . | 4.6 | 7.0 | 1.6 |
| Heart, aorta, lungs, windpipe, liver, gall-bladder and contents, pancreas, spleen, and blood . . . . . . . | 7.0 | 7.3 | 6.6 |
| Other offal parts . . . . . . . | 13.0 | 15.0 | 1.1 |
| Total offal parts . . . . . . . . | 38.9 | 40.2 | 16.8 |
| Carcass . . . . . . . . . | 59.3 | 59.7 | 82.6 |
| Loss by evaporation, &c. . . . . . | 1.8 | 0.1 | 0.6 |
| Total . . . | 100.0 | 100.0 | 100.0 |
| PER 100 LIVE-WEIGHT. | | | |
| Dry substance consumed in food per week . | 12.5 | 16.0 | 27.0 |
| Increase yielded per week . . . . . | 1.13 | 1.76 | 6.43 |
| PER 100 DRY SUBSTANCE OF FOOD. | | | |
| Fat in increase . . . . . . . . | 5.2 | 7.0 | 15.7 |
| Total dry substance in increase . . . . | 6.2 | 8.0 | 17.6 |
| Total dry substance in excretions . . . | 36.5 | 31.9 | 16.7 |
| AVERAGE FAT PER CENT. | | | |
| In lean condition . . . . . . . | 16.0 | 18.0 | 22.0 |
| In fat condition . . . . . . . . | 30.0 | 33.0 | 44.0 |
| In increase whilst fattening . . . . | 60.0 | 65.0 | 70.0 |

Thus, as compared with either oxen or sheep, the pig offers many advantages as a subject for the consideration of the relations of food and increase, and consequently for that of the source in the food of the fat which he yields. He has a *Pigs most suitable for experiments.*

less proportion of alimentary organs and contents; he consumes more food in proportion to his weight; he yields a larger proportion both of total increase and of fat; and finally, much less of his food is effete and voided. The general result is, that changes in his live-weight are in a much less proportion influenced by variations in the contents of the alimentary organs, and are, therefore, much truer indications of change in the substance of the body; and hence the range of error in calculating the amount and composition of his increase in relation to the amount and composition of the food consumed, is much less.

### *The Experiments at Rothamsted with Pigs.*

In the selection of the experiments with pigs, for calculating whether more fat was stored up than could possibly have been derived from the ready-formed fat and the nitrogenous substance of the food, some have been taken in which the proportion of the nitrogenous to the non-nitrogenous constituents of the food was abnormally high, and others in which it was fairly normal, or even low. In all cases, the experiments were conducted for periods of not less than eight or ten weeks; and the amounts, both of total increase, and of fat stored up, were so large in proportion both to the original weight of the animal, and to the amount of food consumed, that the data obtained may safely be relied upon for the settlement of the question at issue.

*Table 70 explained.* In the upper portion of the next Table (70) are recorded some particulars of the nine experiments selected for calculation—namely, the description of the food, the number of animals experimented upon, the duration of the experiment, the original and final live-weights, the increase per head and on 100 original weight, the percentage of carcass in fasted live-weight, and the amount of crude non-nitrogenous to 1 of crude nitrogenous substance in the food.

The middle division of the table shows, *for* 100 *increase in live-weight*—the amount of nitrogenous substance consumed in the food, the amount of it estimated to be stored up in the increase, and the quantity remaining, and therefore possibly available for the formation of fat. Next, there are given—the estimated amount of fat in the increase, the amount ready-formed in the food, and the difference—that is, the amount newly-formed. There are then given—the amounts of carbon in the estimated newly-formed fat, the amounts in the available nitrogenous substance *minus* that in the urea formed, supposing the whole of the nitrogen not stored up in increase to contribute to such formation; and lastly, the dif-

ference, that is, the amount of carbon available from the nitrogenous substance for the formation of fat, more or less than that required for the amount of fat produced.

Then, in the bottom division of the table are shown, *for* 100 *of carbon in the estimated produced fat*—the amount available from the nitrogenous substance, and the amount not available from that source, in each experiment; the amount not so available representing, of course, the proportion required from other sources.

It is hardly necessary to point out, that according to the above mode of illustration, the figures show, not only the utmost proportion of the stored up fat which could possibly have had its source in the nitrogenous substance of the food, but notably more than could possibly have been so derived. Thus, to say nothing of other considerations, it has been assumed, for simplicity of illustration, and for the sake of argument, that the whole of the nitrogenous substance of the food not stored up as increase would be perfectly digested, and be available for fat-formation; and that, in the breaking up of the nitrogenous substance for the formation of fat, no other carbon compounds than fat and urea would be produced; and lastly, that the whole of the ready-formed fatty matter of the food has contributed to the fat stored up. It is obvious, however, that these assumptions are in part improbable, and in part quite inadmissible; whilst the tendency of the error is, in each case, to show too large a proportion of the stored up fat to have been possibly derived from the ready-formed fat, and the nitrogenous constituents, of the food.

*Amount of fat derived from other sources greater than the figures show.*

It is obvious, therefore, that where the figures show an excess of carbon available from nitrogenous substance over that which would be required if the produced fat had been formed from it, the excess is over-estimated; and, on the other hand, that where they show a deficiency of nitrogenous substance for such formation, the deficiency is under-estimated; so that, in fact, the amount of fat required to be derived from other sources would be greater than the figures indicate. Indeed, according to the mode of calculation adopted, 100 of nitrogenous substance would yield 62 parts of fat; but it has been fully admitted in subsequent discussions, that at most 51.4 parts of fat could possibly be derived from 100 parts of proteid substance; and more recently a much lower figure has been adopted.

*Results.*

After these general remarks, we may now turn to the consideration of the results of the different experiments.

In experiment 1, two pigs of the same litter, of almost exactly equal weight, and, as far as could be judged, of similar character, were selected. One was killed at once, and the

TABLE 70.—Relation of the Total Fat in the Increase to the Ready-Formed Fatty Matter in the Food, and of the Carbon in the Fat produced within the Body to that in the Nitrogenous Substance consumed, in Experiments with Fattening Pigs.

| Experiments | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 3 lb. 3 oz. lentil-meal, and 9 oz. bran, per head per day and | | | |
| | Bean-meal, lentil meal, and bran, each 1 part, barley-meal 3 parts. | Bean meal, lentil-meal, bran, and maize-meal, each *ad lib.* | Mixture, equal parts bran and lentil-meal *ad lib.* | Maize meal *ad lib.* | Barley-meal *ad lib* | Sugar *ad lib.* | Starch *ad lib.* | Sugar and starch, each *ad lib.* | Lentil-meal, bran, sugar, and starch, each *ad lib.* |
| **CONDITIONS, AND ACTUAL RESULTS OF EXPERIMENTS.** | | | | | | | | | |
| Number of animals | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Duration of experiment—weeks | 10 | 8 | 8 | 5 | 8 | 10 | 10 | 10 | 10 |
| Original live-weight per head, lb. | 103 | 143 | 147 | 144 | 119 | 95 | 95 | 94 | 97 |
| Final live-weight per head, lb. | 191 | 228 | 248 | 217 | 216 | 178 | 178 | 184 | 201 |
| Increase in live-weight per head, lb. | 88 | 85 | 101 | 73 | 97 | 83 | 83 | 90 | 104 |
| Increase on 100 original weight | 85.4 | 59.7 | 68.0 | 51.3 | 64.9 | 86.4 | 87.0 | 96.8 | 106.8 |
| Per cent carcass in live weight | 82.8 | 83.9 | 81.9 | 85.4 | .. | 83.1 | 80.1 | 81.7 | 80.8 |
| Non-nit. sub. to 1 nit. sub. in food (crude) | 3.6 | 3.3 | 2.0 | 6.6 | 6.0 | 4.1 | 4.1 | 4.7 | 3.9 |
| **PER 100 INCREASE IN LIVE-WEIGHT.** | | | | | | | | | |
| Nitrogenous substance — In food | 100.0 | 107.0 | 138.0 | 57.0 | 64.0 | 81.0 | 81.0 | 74.0 | 82.0 |
| Nitrogenous substance — In increase | 7.8 | 6.1 | 6.7 | 5.3 | 6.5 | 7.5 | 7.6 | 8.0 | 8.2 |
| Available for fat-formation | 92.2 | 100.9 | 131.3 | 51.7 | 57.5 | 73.5 | 73.4 | 66.0 | 73.8 |
| Fat — In increase | 63.1 | 73.9 | 69.6 | 79.0 | 71.2 | 64.1 | 63.9 | 62.0 | 59.9 |
| Fat — In food | 15.6 | 20.4 | 11.2 | 26.3 | 12.4 | 7.9 | 7.9 | 7.3 | 6.6 |
| Newly formed | 47.5 | 53.5 | 58.4 | 52.7 | 58.8 | 56.2 | 56.0 | 54.7 | 53.3 |
| Carbon — In newly-formed fat | 36.6 | 41.2 | 45.0 | 40.6 | 45.3 | 43.3 | 43.1 | 42.1 | 41.0 |
| Carbon — In available nit. sub. *minus* urea | 44.0 | 48.1 | 62.6 | 24.7 | 27.4 | 35.1 | 35.0 | 31.5 | 35.2 |
| More (+) or less (−) in nit. sub. than required | +7.4 | +6.9 | +17.6 | −15.9 | −17.9 | −8.2 | −8.1 | −10.6 | −5.8 |
| **PER 100 CARBON IN ESTIMATED NEWLY-FORMED FAT.** | | | | | | | | | |
| Carbon — In available nit. sub. *minus* urea | 120.2 | 116.7 | 139.1 | 60.8 | 60.5 | 81.1 | 81.2 | 74.8 | 85.9 |
| Carbon — Not available from nitrogenous substance | .. | .. | .. | 39.2 | 39.5 | 18.9 | 18.8 | 25.2 | 14.1 |

amount of total dry or solid matter, of nitrogenous substance, of fat, and of mineral matter, determined in it. The other was then fed for a period of ten weeks, on a mixture consisting of—bean-meal, lentil-meal, and bran, each 1 part, and barley-meal 3 parts, given *ad libitum*. It was then weighed, killed, and its composition determined as in the case of the other animal. In fact, the object of the experiment was, to determine the composition of a "*store*" and of a "*fat*" pig, and to estimate the composition of its increase whilst fattening; and the data thus provided have formed the basis of the estimate of the fat in the increase, not only in the case of experiment 1, to which they directly apply, but in that of each of the other eight experiments, the results relating to which are recorded in the table. On this point it may be observed that, taking into consideration the weight and condition of the animals at the commencement, the character of the foods, the length of the fattening period, the proportion of increase upon the original live-weight, and the final condition of the animals, it may perhaps be concluded, that the tendency of error in the calculations would be to give the proportion of fat in the increase somewhat too high in experiments 2 and 3, and somewhat too low in experiments 6, 7, 8, and 9. In experiments 4 and 5, however, the animals were the fattest in the series; and it will be seen further on, that the high estimates of fat in the increase in their case are probably not too high—indeed, in experiment 5 even somewhat too low.

It might be supposed that, at any rate in the case of experiment 1, the results would be admirably adapted for our present purpose. But that experiment was made in 1850, that is nearly forty-five years ago, and before we had acquired sufficient evidence against the view then prevailing—namely, that the increase of the fattening animal was largely dependent on the richness of the food in nitrogenous constituents; and everybody having experience in the fattening of pigs will admit that, in this case, the food was much more highly nitrogenous than is recognised as most favourable for the fattening of the animal. In fact, it is seen that the proportion of the crude non-nitrogenous to 1 of crude nitrogenous substance in the food, was only 3.6 instead of about 6, as in barley-meal. There was, therefore, an excess of nitrogenous substance consumed.

*Excess of nitrogenous substance in the food.*

Referring to the middle division of the table, the calculated results show that, *for* 100 *increase in live-weight*, 100 of nitrogenous substance was consumed in the food. Of this, it is estimated that only 7.8 parts were stored up in the increase, leaving 92.2 parts available for the possible formation of fat.

It is next seen, that the 100 of increase was estimated to contain 63.1 parts of fat, whilst the food supplied only 15.6 parts, leaving therefore, at least, 47.5 parts to be produced within the body. The figures show that this would require 36.6 parts of carbon, whilst 44.0 parts are estimated to have been available from the nitrogenous substance of the food; leaving, therefore, according to the mode of calculation adopted, 7.4 parts more carbon available than were required for the formation of the produced fat. Or, as shown in the bottom division of the table, *for* 100 *carbon in the estimated newly formed fat*, 120.2 parts were available from the nitrogenous substance consumed in the food.

*Results hardly correct.* Here, then, the calculations afford no evidence that fat must have been produced from carbohydrates. But, as already explained, the mode of estimate adopted assumes the whole of the ready-formed fat in the food to have been stored up, and the whole of the carbon of the nitrogenous substance, beyond that in the animal increase, and in the urea formed, to have been utilised for fat formation. Neither of these assumptions is, however, admissible; and it will be seen further on, when due correction is made in regard to these points, that, even in this experiment, with so abnormally high a proportion of nitrogenous substance in the food, it is pretty certain that some of the produced fat must have had its source in the carbohydrates.

In experiment 2, the food consisted of bean-meal, lentil-meal, bran, and maize-meal, each given separately, and *ad libitum;* and in experiment 3, of an equal mixture of bean-meal and lentil-meal, also given *ad libitum*. It is seen that, in both cases, the proportion of crude non-nitrogenous to 1 of crude nitrogenous substance in the food was even lower than in experiment 1: being, in experiment 2, 3.3, and in experiment 3, only 2.0, against 3.6 in experiment 1. Here again, as might be expected, with so high a proportion of nitrogenous substance in the food, the calculations show that there was more than sufficient carbon available from the nitrogenous substance of the food for the formation of all the fat that was estimated to be produced.

*Nitrogenous substance again in excess.*

Experiments 4 and 5 show a very different result. In experiment 4 the food consisted of maize-meal alone, and in experiment 5 of barley-meal alone, in each case given *ad libitum*. In America especially, maize-meal is largely used for the fattening of pigs, almost, if not quite alone; and in our own country barley-meal is undoubtedly recognised as the most appropriate fattening food of the animal. It is seen that, in experiment 4, with maize-meal, the proportion of crude non-nitrogenous to 1 of nitrogenous substance in the

*Appropriate food for pigs.*

food was 6.6, and in experiment 5, with barley-meal, it was 6.0; or, in both cases, nearly that which is recognised as appropriate in the fattening food of the animal, but rather low in nitrogenous substance.

Accordingly, the calculations show much less nitrogenous substance consumed for the production of 100 increase in live-weight, and much less left available for fat formation, after deducting the amount estimated to be stored up in the increase. Then, as to the fat, the animals were undoubtedly much fatter than the analysed "*fat*" pig. Deducting the amounts of fat supplied in the food from that in the increase, there remained, in the one case 52.7, and in the other 58.8 parts, formed within the body, requiring in the first case 40.6, and in the second 45.3 of carbon; whilst the amounts of carbon estimated to be available from the nitrogenous substance of the food were only 24.7 and 27.4 parts; leaving, in the one case 15.9, and in the other 17.9 parts, to be provided from other constituents of the food. Or, if the calculations are made for 100 *carbon in the estimated newly-formed fat*, the figures show that, in one case 39.2, and in the other 39.5 per cent, of the total carbon of the produced fat must have been derived from other constituents of the food.

*40 per cent fat derived from carbohydrates.*

In other words, even on this mode of calculation, nearly 40 per cent of the newly-formed fat must have had its source in the carbohydrates. We shall see further on, that even a considerably larger proportion still must in reality have been so derived.

The peculiarity of the experiments 6, 7, 8, and 9 was, that the food contained less ready-formed fat than in any of the other cases, and that a large proportion of the non-nitrogenous substance supplied was in the form either of pure starch, pure sugar, or both. In experiments 6, 7, and 8, a fixed quantity of lentil-meal and bran, averaging 3 lb. 3 oz. of lentil-meal, and 9 oz. of bran, was given per head per day; and, in addition, in experiment 6 sugar *ad libitum*, in experiment 7 starch *ad libitum*, and in experiment 8 sugar and starch, each separately, *ad libitum*. Lastly, in experiment 9, lentil-meal, bran, sugar, and starch, were each given separately, and *ad libitum*. It will be seen that the proportion of crude non-nitrogenous to 1 of crude nitrogenous substance was 4.1 in experiments 6 and 7, 4.7 in experiment 8, and only 3.9 in experiment 9; that is, the food contained a higher proportion of non-nitrogenous substance than in experiments 1, 2, and 3, but considerably lower than in experiments 4 and 5. Accordingly the final result of the calculations is intermediate between that for the other two series.

To go a little into detail, it is seen that, *for* 100 *increase in live-weight*, the amount of nitrogenous substance estimated to be available for fat-formation was, in this series, intermediate between that in the other two. With much less fatty matter supplied in the food, the amount or fat estimated to be newly-formed was about the same as in the other cases. The amount of carbon estimated to be available for fat-formation from the nitrogenous substance of the food was, in each case, notably less than the amount required for the production of the newly-formed fat. The indication is, therefore, that in each case a considerable proportion of the produced fat must have had its source in other than the nitrogenous constituents of the food.

*[illegible]*

The bottom division of the table shows that, reckoned for 100 carbon in the estimated newly-formed fat, in the first case 18.9, in the second 18.8, in the third 25.2, and in the fourth 14.1 per cent, or, on the average, about 20 per cent of the whole must have been derived from other sources—in fact from the carbohydrates. Nor can there be any doubt that the figures under-estimate the proportion of the produced fat which could not have had its source in the albuminoids of the food.

*General result.*

The general result of the whole series of experiments is, then, that when the food of the fattening animal contains an abnormally high amount and proportion of nitrogenous substance, enough of it will probably be available for the possible formation of all the fat produced in the body; but that, when the amount and proportion of such substances in the food are only normal, or low, there will remain a large proportion of the produced fat which could not have had its source in the proteids, and must have been derived from the carbohydrates.

*Voit criticises the Rothamsted results.*

Referring to our results and conclusions as given above, Professor Voit, in a paper which he published in 1869,[1] admits that in the experiments in which there was only a medium albuminoid supply in the food, there was, as the figures stand, a considerable deficiency for the formation of the fat produced, and a still greater deficiency when the relation of the nitrogenous to the non-nitrogenous constituents was lower still; and hence it would appear that in these instances a considerable amount of fat had been derived from the carbohydrates. Still, he says, he cannot allow himself to consider that a transformation of carbohydrates into fat is proved thereby. He says he has not been able to get a clear view of the experiments from the figures recorded, and suggests

[1] *Zeitschrift für Biologie*, Band 5.

several possible sources of error. He proposed that new experiments with geese and with pigs should be made; and, in a subsequent conversation one of us had with him, he expressed his willingness to undertake a conclusive experiment with pigs.

*Experiments by Weiske and Wildt.* Weiske and Wildt[1] did undertake an investigation with pigs to determine the point. But one animal was fed on food so rich in nitrogen that it suffered in health, and the experiment had to be discontinued; and the other on food so poor, that it fattened extremely slowly, and hence, at the conclusion, calculation showed that there was enough of the consumed nitrogenous matter available for fat formation to cover the whole of the fat which had been produced.

*Wolff's views.* Professor Emil von Wolff, in his work entitled *Die rationelle Fütterung der landwirthschaftlichen Nutzthiere, auf Grundlage der neueren Thier-physiologischen Forschungen*, published in 1874, assumed that albumin was probably the exclusive source of the fat of the fattening herbivora of the farm. But he made the reservation, that the amounts of increase produced in relation to constituents consumed, which common observation showed may be obtained with pigs, and still more the results recorded of some direct experiments with those animals (presumably our own), are almost incomprehensible without assuming the direct concurrence of the carbohydrates in the formation of the fat. Nevertheless, he considered that such evidence was inconclusive, and that experiments with pigs should be made in a respiration apparatus to settle the question.

*Re-calculation of Rothamsted experiments.* After the inconclusive results of Weiske and Wildt, and the publication of Professor Wolff's views, as above quoted, we carefully reviewed and re-calculated many of the results of our feeding experiments, including some with oxen and with sheep as well as those with pigs, in order to satisfy ourselves whether any doubt could be entertained of the views we had previously advocated.

*Source of fat in cattle.* The result of this examination, so far as the ruminants were concerned, was to show that, owing to the comparatively small amount of increase obtained with them from a given amount of constituents consumed, the quantity of nitrogenous substance passed through the system for the production of a given amount of increase was, in most cases, so large as to admit of the assumption that the whole of the fat formed might have had its source in transformed nitrogenous matter. *Source of fat in sheep.* As will be seen further on, however, some of the experiments with sheep showed that, at any rate part of the fat stored up

[1] *Zeitschrift für Biologie*, Band 10.

must have had some other source than the fatty matter and the proteids of the food.

*Views as to fat in pigs confirmed.*

The reconsideration of the results with pigs fully confirmed the view that, in many cases, much more fat had been produced than could possibly have been derived from transformed albumin of the food. We concluded, therefore, that we were not called upon to institute new experiments; and decided instead, again to direct attention to the results which had already been published.

*Paper read at Hamburg in 1876.*

Accordingly, we gave a paper on the subject in the Section for Agriculture and Agricultural Chemistry, at the meeting of the *Naturforscher Versammlung*, held at Hamburg, in 1876, at which there were present a number of the chief agricultural chemists of Germany. The results given in Tables 69 and 70 were discussed, and it was pointed out that, even according to the mode of calculation adopted, which would imply about 62 parts of fat to be producible from 100 parts of nitrogenous substance, the experiments 4 and 5, in which the proportion of the non-nitrogenous to the nitrogenous constituents in the food was the most appropriate for fattening, showed that about 40 per cent of the produced fat could not have had its source in the nitrogenous substance consumed; whilst if, according to Henneberg and Voit, it were assumed that 100 parts of albumin can at most yield 51.4 of fat, the results would be much more striking still. They would, of course, be still more so if, as has more recently been estimated, only 42 instead of 51.4 parts of fat can be derived from 100 of albumin.

It was next considered what amount of error in the estimates would have to be admitted to turn the scale, and to show that the whole of the produced fat might have been derived from the albuminoids of the food. After going into considerable detail on the point, it was concluded that any such range of error was simply impossible.

*A test experiment.*

Further, it was maintained that, in the case of pigs fattening rapidly on their most appropriate fattening food, the amount of fat stored up in proportion to the amount of fat and nitrogenous substance consumed was so large that the question of whether or not the carbohydrates contribute to fat-formation might be conclusively settled by a properly conducted feeding experiment with those animals, without any analysis of the fæces or the urine, or any determination of the products of respiration. It was stated that it was only necessary to select two animals of a breed of good fattening quality, and as nearly alike as possible in character and in weight; a convenient size and weight being—say about 90 lb. per head. Each should then be fed with ground barley of good quality, giving it, by degrees, until both weighed about

100 lb. Then slaughter one, and determine its total amount of nitrogenous substance and of fat. Continue to feed the other with barley meal (and water) exclusively, as much as it will consume, until it reaches a weight of about 200 lb.; then slaughter and analyse it as the first. The quantity and composition of the food must, of course, also be determined. Such an animal would probably consume about 500 lb. of barley, and increase in live-weight from 100 to 200 lb., in from eight to ten weeks—more or less, according to the quality of the animal, the quality of the food, and other conditions. It was desirable that the animals selected should have been feeding on fairly good food previously, so that the transition to full fattening food should not be too sudden. It was also, of course, desirable, that the experiments should be made in duplicate if possible.

*Professor Henneberg's opinion.*

In the discussion which followed, Professor Henneberg, who was, we believe, the first to have a Pettenkofer respiration apparatus constructed for experimenting with the larger animals of the farm, and had perhaps, at that time, conducted more experiments on feeding than any other agricultural chemist in Germany, said he did not doubt the formation of fat from carbohydrates in the case of pigs. He added, that probably sooner or later the carbohydrates would be restored to their former position so far as fat-formation in other animals was concerned, for already some experiments had shown that such formation was quite close upon the limits of the amount possibly derivable from the fat albuminoid matters of the food. Professor Emil von Wolff also spoke in the same sense so far as pigs were concerned.

*Wolff's opinion.*

Since that time, experiments have been made on the subject in Germany with various animals; but, even in those with pigs, the conditions above indicated as desirable with a view to obtaining decisive results the most easily, were not followed.

*Experiments in Germany with cows.*

Experiments were made with cows by Voit at Munich,[1] by Wolff at Hohenheim,[2] and by G. Kuhn at Mockern.[3] In those at Munich and at Hohenheim, the amount of fat in the food, and that possibly derivable from the albumin consumed, very nearly corresponded with the amount of fat in the milk. In the experiments at Möckern, however, a small excess of milk-fat was produced. None of these experiments, therefore, afforded evidence of the formation of fat from the carbohydrates.

[1] *Zeitschrift fur Biologie*, 1869, p. 113.
[2] *Die Versuchsstationen, Hohenheim*, Berlin, 1870, p. 50; also M. Fleischer in *Virchow's Archiv fur Patholog. Anat.*, Band 51, 1870.
[3] *Versuchsstationen*, 1869, Band 12, p. 451.

*Experiments in Germany with sheep.* In experiments made by Kern and Wattenberg, at Göttingen[1] with sheep of various ages, in ten cases the fat stored up fell short by 24 to 64 per cent of that which could have been derived from the fatty matter and nitrogenous substance consumed. In one experiment, however, one animal was killed and the initial composition determined, and the other was fed for ten weeks, and the composition and digestibility of the food were determined. The results showed that 29.4 per cent of the fat stored up must have been derived from other sources than the fat and the albumin of the food; and, even making all allowance for possible error, it was concluded that fat must have been derived from the carbohydrates consumed.

In other experiments at Göttingen, by T. Pfeiffer and Lehmann,[2] a similar result was obtained with a sheep fed with a considerable quantity of sugar.

*Wolff's experiments with pigs.* In an experiment made by Wolff at Hohenheim,[3] a young pig was fed for 108 days with barley and maize-meal, with the addition of pure starch. The constituents digested were determined. Referring to the results, Wolff says that, having regard simply to the amounts of constituents consumed, and of increase produced, it is scarcely possible to suppose that the quantity of fat which must have been stored up could have been formed without the co-operation of the carbohydrates. He points out that fat equal to only 29 per cent of the increase in live-weight could have been produced from the fat and the albumin of the food; and in this calculation he takes the whole of the albumin as available, without reckoning any to have been stored up. He adds that, according to the percentage of fat in increase in the Rothamsted experiment No. 1, there must have been 60 per cent or more. *Rothamsted view of Wolff's experiment.* According to our own calculation of Wolff's results, it seems probable that about 60 per cent of the total fat in the increase must have been derived from carbohydrates. It is particularly to be observed that, in the case of this experiment, Wolff concluded that the formation of fat from the carbohydrates might be considered established, not only without any respiration apparatus, but even without any direct determination of fat in the animal.

*Various experiments confirming Rothamsted results.* Wolff quotes the results of experiments with pigs at Moscow, by Tschirwinsky, in 1880-81 and in 1881-82.[4] It was estimated that in the one case 61.6 per cent, and in the other 76.9 per cent of the fat of the increase must have had its source in the carbohydrates of the food.

[1] *Journ. für Landw.* Jahrg. 26, p. 549.
[2] *Journ. für Landw.* 1885, Band 33, p. 337; also 1886, Band 34, p. 83.
[3] *Die rationelle Fütterung der landwirthschaftlichen Nutzthiere,* 5te Aufl., 1888, p. 48.
[4] *Versuchsstationen,* 1883, Band 29, p. 317.

In an experiment made with a pig at Vienna by Meissl and Strohmer,[1] it was estimated that 82.2 per cent of the stored-up fat must have been derived from the carbohydrates consumed.

At Proskau, Weiske and B. Schulze[2] made experiments with geese; and they concluded that in one case 13 per cent, and in the other 17.6 per cent of the stored-up fat must have been derived from carbohydrates.

At Peterhof, near Riga, Chaniewski[3] experimented with geese; and from the results concluded that in one case 71.1 per cent, in another 78.6 per cent, and in a third 86.7 per cent of the stored-up fat must have been derived from carbohydrates.

Wolff also quoted recent experiments by A. von Planta and Erlenmeyer, at Munich, with bees,[4] in which it was proved that wax had been formed from sugar.

*Recent experiments by Soxhlet.*

Lastly, in 1880-81, Soxhlet made experiments with three pigs, at the Agricultural Experiment Station at Munich.[5] The animals were five to six months old; they were fed for a preliminary period of 321 days, with equal but limited amounts of barley-meal. No. 1 was then killed and analysed; No. 2 was fed for 75 days, and No. 3 for 82 days, with 4.4 lb. steamed rice per head per day for most of the time, but only three-fourths as much afterwards. Meat extract was also given for 50 days. Finally, Nos. 2 and 3 were killed and analysed. Calculation showed that the increase of No. 2 contained 14.19 per cent of nitrogenous substance, and 25.80 per cent of fat; and that of No. 3, 7.25 per cent of nitrogenous substance, and 57.23 per cent of fat. That is, the increase of No. 3 contained only half as much nitrogenous substance, and more than twice as much fat, as that of No. 2; and even the higher proportion of fat (57.23) is low compared with that which would be obtained with animals of good breed, and rapidly fattened on appropriate food given *ad libitum;* whilst the composition of the increase of No. 2, both as to nitrogenous substance and fat, can hardly be called that of fattening increase at all. Still, calculation showed that, of the total fat in the increase of No. 2, 79.38, and in that of No. 3, 81.84 per cent, must have been derived from the carbohydrates of the food.

Notwithstanding the extraordinary difference in the composition of the increase of Soxhlet's pigs No. 2 and No. 3,

[1] *Ber. Acad. Wissens.*, Wein, 1883, Band 88, p. iii.

[2] and [3] E. Wolff, *Die rationelle Fütterung der landwirthschaftlichen Nutzthiere*, 5te Aufl., 1888, p. 50.

[4] *Bienenzeitung v. A. Schmidt*, 1878, p. 181.

[5] *Zeits. d. landw. Vereins in Bayern*, 1881, pp. 423-436.

after having been fed alike, he says that only our experiment No. 1 is admissible for calculation, because it is only in that case that the initial and final composition was determined in parallel animals. He, in fact, accepts our least conclusive result, obtained with food abnormally rich in nitrogenous substance, and repudiates our most conclusive experiments with appropriate fattening food. Accordingly he maintains that we had only shown the probability of the formation of fat from the carbohydrates, and that his own results as above were the first to prove it.

The discussion of the results of the nine experiments recorded in Table 70 must have sufficed to show that in some of them a very large proportion of the fat of the increase must have been produced from the carbohydrates. The mode of calculation adopted showed, however, a maximum amount of the fat of the increase to have been possibly derivable from fatty matter in the food, a maximum amount of the nitrogenous substance of the food to be available for fat-formation, and a maximum amount producible from a given amount of nitrogenous substance; and hence a minimum amount necessarily derived from carbohydrates. But, as the results so calculated, and discussed with due reservation on these points, are those upon which we have for so many years maintained that the formation of fat from the carbohydrates has been proved, and as it is those results, and the conclusions drawn from them, that have instigated so much subsequent investigation leading to the confirmation of our views, it seemed desirable prominently to direct attention to the evidence as so brought out.

We have, however, as already said, long ago re-calculated many of our feeding experiments, making allowance, as far as practicable, for the probable amount of indigestible and necessarily effete matters of the foods. We have also, as referred to at pp. 280-283, arranged tables founded on our direct analytical results on the ten animals, showing the probable average percentage composition of the different descriptions of animal, each at eight gradationary points from the store to the very fat condition, and have applied the factors thus obtained, not only for the calculation of the composition of the increase in a number of cases of ordinary practice, and of direct experiment, but also for the re-calculation of some of the results to which Table 70 relates. Accordingly, in the next Table (71) are given the results obtained in experiment No. 1, which were inconclusive according to the original mode of calculation, and also those obtained in experiments 4 and 5, which, even as originally calculated, could

*Table 71 explained.*

TABLE 71.—SOURCES OF THE FAT OF THE ANIMAL BODY. ABSTRACT OF RESULTS OF EXPERIMENTS MADE AT ROTHAMSTED WITH PIGS. RESULTS RECKONING 100 NITROGENOUS SUBSTANCE IN FOOD MAY YIELD 51.4 FAT.

| | | Experiment 1. Bean-meal, lentil-meal, and bran, each 1 part, barley-meal 3 parts. | | | Experiment 4. Maize-meal, *ad lib.* | | | Experiment 5. Barley-meal, *ad lib.* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Proportion of nit. sub. and fat digested | | All | 90 p.c. | 80 p.c. | All | 90 p.c. | 80 p.c. | All | 90 p.c. | 80 p.c. |
| Albuminoid ratio[1] | | 3.8 | 3.8 | 3.8 | 7.3 | 7.3 | 7.3 | 6.3 | 6.3 | 6.3 |
| **FOR 100 INCREASE IN LIVE-WEIGHT.** | | | | | | | | | | |
| Nitrogenous substance | In food | 100.0 | 90.0 | 80.0 | 57.0 | 51.3 | 45.6 | 64.0 | 57.6 | 51.2 |
| | In increase | 7.8 | 7.8 | 7.8 | 5.4 | 5.4 | 5.4 | 6.4 | 6.4 | 6.4 |
| | Available for fat-formation | 92.2 | 82.2 | 72.2 | 51.6 | 45.9 | 40.2 | 57.6 | 51.2 | 44.8 |
| Fat | In increase | 63.1 | 63.1 | 63.1 | 79.0 | 79.0 | 79.0 | 72.3 | 72.3 | 72.3 |
| | In food | 15.6 | 14.0 | 12.5 | 26.3 | 23.7 | 21.0 | 12.4 | 11.2 | 9.9 |
| | Newly-formed | 47.5 | 49.1 | 50.6 | 52.7 | 55.3 | 58.0 | 59.9 | 61.1 | 62.4 |
| | Derivable from nit. sub. | 47.4 | 42.3 | 37.1 | 26.5 | 23.6 | 20.7 | 29.6 | 26.3 | 23.0 |
| | From carbohydrates | 0.1 | 6.8 | 13.5 | 26.2 | 31.7 | 37.3 | 30.3 | 34.8 | 39.4 |
| **FOR 100 TOTAL FAT IN INCREASE.** | | | | | | | | | | |
| Fat | From fat in food | 24.7 | 22.2 | 19.8 | 33.3 | 30.0 | 26.6 | 17.2 | 15.5 | 13.7 |
| | Derivable from nit. sub. | 75.1 | 67.0 | 58.8 | 33.5 | 29.9 | 26.2 | 40.9 | 36.4 | 31.8 |
| | From carbohydrates | 0.2 | 10.8 | 21.4 | 33.2 | 40.1 | 47.2 | 41.9 | 48.1 | 54.5 |
| **FOR 100 NEWLY-FORMED FAT.** | | | | | | | | | | |
| Fat | Derivable from nit. sub. | 99.8 | 86.1 | 73.3 | 50.3 | 42.7 | 35.7 | 49.4 | 43.0 | 36.9 |
| | From carbohydrates | 0.2 | 13.9 | 26.7 | 49.7 | 57.3 | 64.3 | 50.6 | 57.0 | 63.1 |

[1] In the calculation of these ratios, the nitrogen is, as in Table 70, multiplied by 6.3 to represent total nitrogenous substance; and for column 1 of each experiment no deduction is made For all three columns of each experiment, the crude-fat is multiplied by 2.4 to bring it into its equivalent of starch. For column 1 the amount of non-nitrogenous substance *not fat*, is taken without deduction; but for columns 2 and 3, as in the case of the nitrogenous substance and the fat, only 90 or 80 per cent, respectively, of the total is assumed to be digested.

leave no doubt of very considerable formation of fat from the carbohydrates.

*Basis of re-calculation.* All these re-calculations are in the first place based on the assumption, since generally adopted by others, that 100 nitrogenous substance can at the most yield 51.4 of fat, instead of nearly 62, which would be the figure according to the original plan of calculation adopted in the construction of Table 70.

*Different calculations.* Then, each experiment is now calculated three ways :—first, on the assumption that the whole of the fatty matter and nitrogenous substance of the food were digested; secondly, supposing that only 90 per cent, and thirdly that only 80 per cent was digestible and available. Lastly, in the case of experiments 4 and 5, after very carefully considering the weights and character of the animals, and the duration of the fattening period, the initial and final composition have been taken, not as in Table 70, the same as in experiment 1, but the initial at a composition three-eighths in advance from the store to the fat condition, and the final composition at a quarter in advance of fatness, compared with the fat pig of experiment 1. It is worthy of remark, that this carefully re-considered independent mode of estimate gives almost precisely the same percentage of nitrogenous substance, and precisely the same of fat, in the *increase* in experiment 4, as in the former estimate—namely, now 5.4 instead of 5.3 per cent of nitrogenous substance, and in both cases 79 per cent of fat, the animals being all very fat. Again, the new mode of calculation gives for experiment 5, 6.4 per cent of nitrogenous substance, and 72.3 per cent of fat in the increase, instead of 6.5 and 71.2 per cent as formerly adopted.

*Results from rich nitrogenous food.* Let us first refer to the results of experiment 1, in which parallel animals were analysed, but in which, as has been pointed out, the food was much more highly nitrogenous than is appropriate in the fattening food of the pig. Those given in column 1, in which it is assumed that the whole, both of the nitrogenous substance and of the fat of the food, was digestible and available, show that, when we now reckon only 51.4 instead of about 62 parts of fat to be derivable from 100 nitrogenous substance, even this experiment indicates that the fat in the food, and that derivable from the nitrogenous substance consumed, were scarcely sufficient to cover the whole of the fat of the increase. Obviously, too, if it be assumed, according to the more recent estimate, that only about 42 parts of fat can be derived from 100 of albuminoid substance, there would then, even in this experiment, with such abnormally high nitrogenous food, be a considerable formation of fat from carbohydrates.

Turning to the results in the second column, which are

calculated on the assumption that only 90 per cent of the nitrogenous substance, and 90 per cent of the fatty matter, of the food would be digested, it is seen that—for 100 increase in live-weight 6.8 parts, for 100 total fat in the increase 10.8 parts, or for 100 newly-formed fat 13.9 parts, must have been derived from carbohydrates.

Lastly, in regard to experiment 1, reckoning only 80 per cent of the nitrogenous substance and fat of the food to have been digested and available, the result would be that 13.5 of the 63.1 parts of fat in 100 of increase must have had some other source than fat and nitrogenous substance of the food; or reckoned for 100 total fat in the increase, 21.4 parts, or for 100 newly formed fat 26.7 parts, must have been derived from carbohydrates.

*Portion of nitrogenous and fatty matters digested.*

In regard to the alternative assumptions that only 90 or only 80 per cent of the nitrogenous and fatty matters of the food were digested, it may be stated that in Wolff's tables, published in *Mentzel und* v. *Lengerke's landwirthschaftlicher Kalender* for 1890, he reckons 88 per cent of the nitrogenous substance of beans, 89.9 per cent of that of lentils, 77.9 per cent of that of bran, 79.2 per cent of that of maize, and 77 per cent of that of barley, to be on the average digested; and of the fatty matter of these foods, he reckons 87.5 per cent of that of beans, 84.6 per cent of that of lentils, 70.6 per cent of that of bran, 85.1 per cent of that of maize, but the whole, or 100 per cent, of that of barley to be digestible. So far, therefore, as experiment 1 is concerned, according to Wolff's factors the truth would lie somewhere between the results supposing 90 and those supposing 80 per cent digested.

*Clear evidence of carbohydrates forming fat.*

Even in this experiment, then (No. 1), there is clear evidence of the formation of fat from the carbohydrates, when deduction is made for indigestible nitrogenous and fatty matters consumed, and when it is reckoned that only 51.4 parts of fat may be produced from 100 albuminoid substance. Obviously, if only 42 parts of fat, as assumed by some, can be formed from 100 albumin the evidence is clearer still.

*Still more decisive.*

Turning now to experiment 4, in which the food was maize-meal alone, given *ad libitum*, and the relation of non-nitrogenous to 1 of nitrogenous substance was much higher than in experiment 1, and much more appropriate for the rapid fattening of the pig, the results are much more decisive. They were indeed quite conclusive as originally calculated, without the emendations now adopted.

The results, even as given in the first of the three columns, in the calculation of which it is assumed that the whole of the nitrogenous substance and fat of the food were digested and available, show that—for 100 increase in live-weight 26.2

*Percentages of fat from carbohydrates.* parts of fat, for 100 total fat in increase 33.2, and for 100 newly-formed fat 49.7 parts, must have been derived from carbohydrates.

Reckoning, as in the second column, that 90 per cent of the nitrogenous substance and fatty matter consumed were digestible and available, the calculations show that—for 100 increase in live-weight 31.7 parts of fat, for 100 total fat in increase 40.1 parts, and for 100 newly-formed fat 57.3 parts, would be derived from carbohydrates. Or, reckoning as in the third column, that only 80 per cent of the nitrogenous substance and fat of the food were digested and available, the results show that—for 100 increase in live-weight 37.3 parts of fat, for 100 total fat in the increase 47.2 parts, and for 100 newly-formed fat 64.3 parts, or nearly two-thirds, of the total produced fat, would have its source in the carbohydrates.

It may be observed that, in the case of this experiment with maize, the results given in the third column would very nearly accord with those which would be obtained if Wolff's average percentages of digestible had been adopted.

*Results with a suitable albuminoid ratio.* Let us now refer to the results of experiment 5, in which the food was barley-meal alone, given *ad libitum*, and the albuminoid ratio was nearly that recognised as most suitable for the rapid fattening of the pig.

The first of the three columns, calculated on the assumption that the whole of the nitrogenous substance and fat consumed were digested, shows that under such conditions there would be—for 100 increase in live-weight 30.3 parts of fat, for 100 total fat in increase 41.9 parts, and for 100 newly-formed fat 50.6 parts, or about half, that must have been derived from other constituents than the fatty matter and nitrogenous substance of the food.

The results in the second column, calculated on the assumption that 90 per cent of the fatty matter and nitrogenous substance were digested, show that—in 100 increase in live-weight 34.8 parts of fat, in 100 of total fat in increase 48.1 parts, and of 100 newly-formed fat 57.0 parts, must have been formed from carbohydrates.

Lastly, the results in the third column, reckoning only 80 per cent of the nitrogenous substance and fat to be digested, show that on this supposition—of 100 increase in live-weight 39.4 parts of fat, of 100 total fat in increase 54.5 parts, or of 100 newly-formed fat 63.1, or again nearly two-thirds, must have been derived from carbohydrates.

*Evidence cumulative and decisive.* So much for the evidence of results relating to pigs, in their bearing on the question of the sources of their fat, when fed on their appropriate fattening food. It is cumulative and decisive that, at any rate, a large proportion of the stored-up

fat must have its source in other constituents than the fat and nitrogenous substance of the food—in other words, *in the carbohydrates.*

### *The Experiments at Rothamsted with Sheep.*

*Experiments with sheep less conclusive.*

It has been pointed out that, compared with pigs, there is with ruminants a much smaller amount of increase obtained, in proportion both to their weight within a given time, and to a given amount of food passed through the body; that there is also a much larger amount of necessarily effete matter in their food; and that, therefore, the result of calculations of feeding experiments with them in regard to the question of the sources in the food of the fat stored up in the body are less conclusive. It will, nevertheless, be of interest to adduce some direct experimental evidence on the point.

*Rothamsted experiments with sheep.*

Some time after the discussion at Hamburg in 1876, two sets of experiments made at Rothamsted with sheep, in which the concentrated foods were barley or malt, and in which, therefore, the amount and proportion of nitrogenous substance consumed was low, were selected for calculation.

The first series comprised five pens, with four or five sheep in each. The experiments had been made in the spring of 1849, and extended over a final fattening period of ten weeks. In each pen barley or malt was given in fixed quantity per head per day, and in each mangels were given in addition, *ad libitum.*

The second series also comprised five pens, but with twelve sheep in each. The experiments were made in the winter of 1863-64, and they extended over a final fattening period of twenty weeks. The animals were at an earlier stage of progress at the commencement, and not quite so mature at the conclusion, as those of the other series. In each pen barley or malt was given in fixed quantity per head, in each clover-chaff also in fixed quantity, and in each roots were given *ad libitum*—swedish turnips during the first sixteen weeks, and a mixture of one-fourth swedes and three-fourths mangels during the last four weeks of the twenty.

The results of these two series of experiments with sheep, calculated to show their bearing on the question of the sources of the fat stored up by the animals, are given in Table 72.

*Table 72 explained.*

It will be seen that the form of the table is, so far as the facts will allow, the same as has been adopted in the case of the various experiments with pigs. A general description of the food of each series is given over the columns

relating to the series, and at the head of each separate column is given a description of the limited food supplied to each pen.

The results are calculated for 100 increase in live-weight. Referring to the upper division of the table, there are first shown—the amounts of nitrogenous substance (digestible) in the fixed food, the amounts in the increase, and the difference = the amounts available for fat-formation. Next are given—the amounts of fat in the increase, in the total food (digestible), and the difference = the newly-formed fat; the amounts derivable from the available nitrogenous substance in the fixed food, and the difference = the amount required to be produced from other sources. Then, in the lower division of the table are given, for each pen, the amounts of fat derivable from the nitrogenous substance of the roots, on the alternative assumptions that 50, 60, 70, 80, 90 per cent, or the whole, of that which they contain will be digestible and available for fat-formation.

*Percentage of nitrogenous substance digested.*

It should be further explained, that 80 per cent of the nitrogenous substance of barley or of malt is reckoned as digestible and available for the purposes of the system. Wolff's estimates were—in 1874, 80 per cent; in 1888, 77.3 per cent; and in 1890, 77 per cent. In malt-dust 80 per cent is assumed to be digestible, against Wolff's estimate of 80 per cent in 1874, and 82 per cent in 1888 and 1890. In clover-chaff two-thirds, or 66.7 per cent, of the nitrogenous substance is reckoned as digestible, against a range in Wolff's Tables, according to quality, from 51.4 to 69.9 per cent. In the cases of Swedish turnips and mangels, Wolff assumes the whole of the nitrogenous substance to be digestible and available, drawing no distinction in this respect between the amounts existing as albuminoids, as amides, or in other forms. To this point we shall have to refer in more detail presently.

*Percentage of fatty matter digested.*

Then as to the fat of the foods: the percentage of it reckoned as digestible is that given in Wolff's tables of 1874. In the case of barley he then reckoned only 68 per cent of the total to be digestible; but more recently he has supposed the whole of it to be so. For clover-chaff his figures are the same at all three periods, as they are also for mangels.

*Results.*

Let us now turn to the calculated results as given in the table, and first to those relating to the first series of five pens, in which the fixed food was either barley or malt, and the *ad libitum* food consisted of mangels only. As already said, the period of experiment comprised only the last ten weeks of fattening. Hence it commenced at a somewhat advanced stage of progress, and the animals were, at the conclusion,

TABLE 72.—SOURCES OF THE FAT OF THE ANIMAL BODY. EXPERIMENTS AT ROTHAMSTED WITH SHEEP. ASSUMED THAT 100 DIGESTIBLE NITROGENOUS SUBSTANCE IN FOOD MAY YIELD 51.4 FAT.

| | | Fixed food—barley or malt; mangels *ad lib.* | | | | | Fixed food—barley or malt, and clover-chaff; roots (swedes and mangels) *ad lib* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| | | Barley. | Malt and malt-dust. | Barley steeped. | Malt and malt-dust steeped. | Malt and malt-dust, extra quantity. | Barley and clover-chaff. | Malt and clover-chaff. | Barley and clover-chaff. | Malt and clover-chaff. | Barley (⅔), malt (⅓), and clover-chaff. |
| PER 100 INCREASE IN LIVE-WEIGHT. | | | | | | | | | | | |
| Nitrogenous substance | In fixed food (digestible) . . | 25.0 | 23.3 | 19.9 | 25.0 | 27.9 | 52.4 | 51.1 | 55.8 | 55.9 | 58 6 |
| | In increase . . . . . | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| | Available for fat-formation | 18.5 | 16.8 | 13.4 | 18.5 | 21.4 | 44.9 | 43 6 | 48.3 | 48.4 | 51.1 |
| Fat . . | In increase . . . . . | 74.0 | 74.0 | 74.0 | 74.0 | 74.0 | 69.0 | 69.0 | 69.0 | 69.0 | 69.0 |
| | In total food (digestible) . . | 10.3 | 8.8 | 9.6 | 10.3 | 10.2 | 13.1 | 12.9 | 13.0 | 13.3 | 13 8 |
| | Newly-formed | 63.7 | 65.2 | 64.4 | 63.7 | 63.8 | 55.9 | 56.1 | 56.0 | 55.7 | 55.2 |
| | Derivable from nit. sub. . . | 9.5 | 8.6 | 6.9 | 9.5 | 11.0 | 23.1 | 22.4 | 24.8 | 24.9 | 26.3 |
| | From other sources | 54.2 | 56.6 | 57.5 | 54 2 | 52.8 | 32.8 | 33.7 | 31.2 | 30.8 | 28.9 |
| FAT DERIVABLE FROM THE NITROGENOUS SUBSTANCE OF THE ROOTS, ACCORDING TO THE PERCENTAGE OF IT CAPABLE OF FAT-FORMATION. | | | | | | | | | | | |
| Fat from nit. sub. of roots | If 50 per cent capable of fat-formation | 22.2 | 20.8 | 24.4 | 26.6 | 23.3 | 14.1 | 14.0 | 14.0 | 14.2 | 14.8 |
| | If 60 " " " | 26.6 | 25.0 | 29.3 | 31.9 | 28.0 | 16.9 | 16.8 | 16.9 | 17.0 | 17.8 |
| | If 70 " " " | 31.1 | 29.1 | 34.2 | 37.2 | 32 6 | 19.7 | 19.6 | 19.7 | 19.9 | 20.7 |
| | If 80 " " " | 35.5 | 33.3 | 39.0 | 42.6 | 37.3 | 22.6 | 22.4 | 22.5 | 22.7 | 23.7 |
| | If 90 " " " | 40.0 | 37.4 | 43.9 | 47.9 | 41.9 | 25.4 | 25.2 | 25.3 | 25.6 | 26.6 |
| | If 100 " " " | 44.4 | 41.6 | 48.8 | 53.2 | 46.6 | 28.2 | 28.0 | 28.1 | 28.4 | 29.6 |

probably fully as fat as, if not fatter than, the sheep which had been analysed as "*fat.*" Taking into account the weight and condition of the animals at the beginning and at the end, and the percentages of carcass and of inside fat in the live-weight, it is calculated that the increase over this short finishing period would contain 74 per cent of fat, and only 6.5 per cent of nitrogenous substance.

*Nitrogenous substance available.* On these assumptions the figures show that, after deducting the estimated amount of nitrogenous substance in 100 of increase from the amount supplied in the fixed food, there remained in the different cases—18.5, 16.8, 13.4, 18.5, and 21.4 parts, of nitrogenous substance available from the fixed foods for the formation of fat.

*Fat available.* Next as to the fat:—deducting the amount of the digestible fat supplied in the total food from the fat in the increase, there remain in the respective cases 63.7, 65.2, 64.4, 63.7, and 63.8 parts, which must have been newly-formed. There is next shown the amount of this which may have been derived from the available nitrogenous substance of the fixed food; and it is seen that there remain—54.2, 56.6, 57.5, 54.2, and 52.8 parts, out of the total of 74 in the 100 of increase, that must have been derived from other sources—in fact, either from the nitrogenous substance of the roots, or from the carbohydrates of the fixed food and the roots.

The next question is, whether the nitrogenous substance of the roots could have yielded the amounts of fat indicated to have been produced from other sources than the fat of the total food, and that derivable from the available nitrogenous substance of the fixed foods. Comparing the figures in the bottom line of the lower division of the table with those in the bottom line of the upper division, it is seen that, even on the impossible assumption that the whole of the nitrogen of the mangels existed in compounds of the same fat-forming value as the albuminoids, in neither of the five cases would the amount so available completely supply the amount required.

*True albuminoid nitrogen in mangels.* The amount of true albuminoid nitrogen varies very much in different descriptions of roots, and in the same description according to season, maturity, &c. Thus, at Rothamsted we have found it in mangels as low as 20.5 per cent of the total nitrogen under unfavourable conditions of growth and ripening, and as high as 44.2 under favourable conditions. We generally assume in calculation that 40 per cent of the nitrogen of mangels will, on the average, exist as albuminoids; and Wolff's average figure, as given in 1888, is 36.1 per cent. *Amides and nitrates in mangels.* The amount existing as amides will probably in most cases vary from 40 to 50 per cent or more, whilst there

is frequently a considerable quantity as nitrates, the more the less ripe the roots; and we have sometimes found the amount to be more than 10 per cent of the total nitrogen of the roots.

*Percentage of nitrogen in mangels available for fat-formation.*

It is clear, therefore, that even supposing as little as 50 per cent of the nitrogen of the roots to be available for, and capable of, fat-formation, as assumed in the top line of the lower division of the table, that amount would generally include other than albuminoid compounds. Nevertheless, Wolff in his tables assumes the whole of the nitrogen of roots to be digestible and available for the purposes of the system, since it has been shown that amides are transformed in the body and yield urea; leaving, therefore, by-products of transformation available for expenditure in respiration, and so protecting the true albuminoids, or the carbohydrates.

*Amides and fat-formation.*

There is, however, so far as we are aware, no direct experimental evidence yet at command, indicating that the by-products of the transformation of amides may directly contribute to the formation of fat. Results of independent experimenters have, however, shown that the heat of combustion of asparagine for example, is only about, or little more than, half that of albumin; and supposing that the amides do directly contribute to the formation of fat, it may safely be concluded that a given quantity of amide would yield very much less fat than an equal quantity of albuminoid. As bearing upon this point, it is to be borne in mind that, on the average, the amide bodies most frequently occurring in food-stuffs have a higher percentage of nitrogen than the albuminoids. Wolff estimates that whilst the nitrogen of food should be $\times 6.25$ to represent albuminoids, 5.5 would, on the average, be a more appropriate factor for calculating the amount of amide from that of the nitrogen. Further, he admits that so far as the nitrogen in potatoes, roots, and other food-stuffs exists as amides, the nutritive value of the food is reduced; nevertheless, as has been said, in his tables he assumes the whole of the nitrogenous substance of roots to be digestible, and of equal value with the albuminoids.

*Wolff's estimate.*

*Nitrates and food value.*

Then, again, as generally more or less of the nitrogen in roots will exist as nitrates, it will so far not only have no food value, but it may be positively injurious. It may be added that, other things being equal, the higher the percentage of nitrogen in roots, the lower as a rule will be the proportion of it as albuminoids, and the higher that as amides, and as nitrates, &c. Further, in direct experiments at Rothamsted with sheep feeding on roots alone, it was found that whilst the animals even gained in weight on ripe roots, low in nitrogen, they actually lost on roots that were less ripe,

*Ripe and unripe roots.*

high in nitrogen, and doubtless containing a larger proportion of their nitrogen as non-albuminoid compounds.

From these various considerations it is obvious that by no means the whole of the nitrogen of the mangels can be estimated as having existed in compounds which could, in their transformation, yield the amount of fat possibly derivable from true albuminoids. However, with the great variation in the proportion of albuminoids and amides in roots, and the absence of exact knowledge as to the probable value, if any, direct or indirect, of amides for fat-formation, it is impossible to form any certain estimate as to which of the percentages given alternatively in the lower division of the table most probably represents the amount of fat producible from the nitrogenous substance of the mangels given *ad libitum* in each of the five pens of the first series of experiments with sheep. It is, however, quite safe to conclude that very much less than the whole would be so available; and if we were to assume that of the nitrogenous constituents of the roots only the albuminoids would be available for fat-formation, the figures given in the top line of the lower division of the table, according to which it is reckoned that only 50 per cent of the total nitrogenous compounds of the roots would be capable of fat-formation, would in each case represent less than half the amount required.

*Amount of fat producible from nitrogen in mangels uncertain.*

*A large proportion of increase derived from carbohydrates.*

It is quite clear that, at any rate a large proportion of the increase estimated to be necessarily derived from other sources than the fat of the total food, and the nitrogenous substance of the fixed food, must have been derived from other sources than the nitrogenous substance of the roots; in other words, it must have had its source in the carbohydrates of the fixed food or of the roots.

Let us now examine the evidence of the results of the second series of experiments, on somewhat similar lines.

As in Series 1, a fixed quantity of barley or malt was given in each pen, but now a fixed quantity of clover-chaff also. This introduction of clover-chaff into the fixed food brings us again face to face with the difficulty as to the estimation of the food-value of the amides. As already said, the calculation of the amounts of the nitrogenous substance in the clover-chaff which will be available are made on the assumption that 66.7 per cent of the total nitrogen will be digestible, and so available; and this figure agrees fairly with Wolff's estimates. But this amount includes amides as well as albuminoids. In Wolff's most recent tables he estimates that the proportion of the nitrogen of clover-hay existing in non-albuminoid compounds may range from 13.9 to 29.9 per cent of the whole, and probably be on the average about 19

*Nitrogen in clover-hay.*

per cent. What proportion, however, of the two-thirds of the total nitrogenous substance of clover-hay, which is estimated to be digestible, will probably be non-albuminoid, there is no evidence to show. Under these circumstances we have, in the calculations, assumed the whole of the digestible nitrogenous substance of clover-hay to have the food-value of albuminoids. The figures will, therefore, doubtless overstate the amount of the nitrogenous substance consumed in the fixed foods, which is really available for nitrogenous increase and for fat-formation.

Taking the figures as they stand, it is seen that, after deducting the amount of nitrogenous substance estimated to be stored up in 100 of increase from the amount supplied in the fixed food, there remain in the several experiments 44.9, 43.6, 48.3, 48.4, and 51.1 parts, possibly available for fat-formation.

Then deducting the amount of digestible fat in the total food from the fat estimated to be stored up in the increase, there remain—55.9, 56.1, 56.0, 55.7, and 55.2 parts, which must have been newly-formed. Deducting from these amounts those producible from the available nitrogenous substance of the fixed foods, there remain—32.8, 33.7, 31.2, 30.8, and 28.9 parts, to be formed from other sources. Comparing with these amounts those derivable from the nitrogenous substance of the roots, assuming, as shown in the bottom line of the table, that the whole of it would have the same value for fat-formation as true albuminoids, it is seen that in four out of the five cases the fat so assumed to be formed would be less than that required.

*Nitrogen in swedes.*

In these experiments the roots consisted chiefly of swedish turnips, and in only small proportion of mangels. The evidence at command leads to the conclusion that, in swedish turnips a larger proportion of the total nitrogen exists as albuminoids, and a less proportion as nitrates, than in the more succulent mangels. We have found the proportion of the total nitrogen of swedish turnips existing as albuminoids as low as 32.9, and as high as 55.8; and for the purposes of calculation we assume that, on the average, 45 per cent will be in that form. As large or a larger amount will, however, exist as amides than in mangels.

It is evident, therefore, that even if we assume 50 per cent of the total nitrogenous substance of the roots consumed in this second series of experiments to have been of value for fat-formation, some amide will be included. But, even on the assumption that 50 per cent had the value of albuminoids for fat-formation, less than half the amount of fat required would be derivable from the nitrogenous substance of the

roots. Assuming, however, that the amides of the roots would, as such, have a certain, though not an equal, value with the albuminoids for fat-formation; or that, as protectors of other constituents, they may contribute indirectly to such formation, there would still remain a considerable amount of the produced fat to be derived from other sources—that is, from carbohydrates.

Upon the whole, then, although the evidence of fat-formation from the carbohydrates of the food is admittedly less direct in the case of sheep than in that of pigs, yet, when the foregoing results are carefully considered with due regard to the facts which have been discussed, no doubt can be entertained that there was a considerable formation of fat from carbohydrates in both of the series of experiments with sheep. *Conclusions with sheep.* And when it is borne in mind that neither of these series of experiments was arranged for the purpose of elucidating this particular question, it must be admitted that the results are more definite and conclusive than might have been anticipated. Nor can there be any doubt that if experiments were made with oxen under suitable conditions, they would yield equally conclusive evidence on the point. Indeed, as anticipated by Henneberg in the observations he made at Hamburg in 1876, *Carbohydrates re-instated.* we may consider that the carbohydrates are re-instated in their position in the formation of the fat of ruminants as well as in that of pigs.

### *Summary on the Sources of the Fat of the Animals of the Farm.*

*Views of German chemists.* It was in 1865—that is, nearly thirty years ago—that Voit first called in question the then very generally accepted opinions on the subject; and as his evidence, derived from experiments with the omnivorous dog, accumulated, he more and more urged that his conclusions were equally applicable to herbivora. His views on the point came to be very generally adopted by agricultural chemists in Germany, and in 1874 Professor Emil von Wolff adopted them, but with some reservation so far as pigs are concerned, in his text-book, entitled, *Die rationelle Fütterung der landwirthschaftlichen Nutzthiere; auf Grundlage der neueren thierphysiologischen Forschungen.*

It has been already stated that, in the discussion at Hamburg in 1876, Wolff more clearly admitted that pigs might behave exceptionally in the matter; whilst Henneberg assumed that ruminants also would prove to be exceptions to the application of Voit's views.

Since that date, a number of experiments have been made

in Germany and elsewhere, both with pigs and with ruminants, to elucidate the point; and when the conditions of the experiments were suited to the object, the results contributed to the re-establishment of the conclusion that the carbohydrates play a very direct and important part in the fat-formation of the animals of the farm.

*Wolff and Voit modifying their opinions.*

Further, in the edition of Wolff's work published in 1888, he almost unreservedly admits the *rôle* of the carbohydrates in the formation of at least a great part of the fat not only of pigs but of ruminants. Indeed, some years previously, Voit himself had made substantial concessions on the point.[1]

*Armsby's Manual of Cattle-Feeding.*

It happens, however, that about 1880 Dr Armsby, now the Director of the Agricultural Experiment Station at the Pennsylvania State College, published a work which has since passed through several editions, entitled *Manual of Cattle-Feeding; a Treatise on the Laws of Animal Nutrition and the Chemistry of Feeding-Stuffs in their application to the Feeding of Farm-Animals,* which was a very good digest, chiefly of the work done in Germany, on the subject.

So far as the question of the sources of fat is concerned, it gives numerous tabular illustrations from Voit's work; and it follows almost exclusively the views of Voit and of Wolff at that time. He, however, quotes results obtained both with pigs and with other animals, which, he admitted, indicate, according to the figures, the formation of fat from the carbohydrates. But he considered that the data at command were not sufficient to solve the problem; and, with Wolff, assumed that the question could not be satisfactorily settled without experiments in a respiration apparatus. He also considered that estimates founded on the composition of the increase of fattening animals as determined at Rothamsted are uncertain. He, nevertheless, concluded that the carbohydrates may serve as a source of fat to swine, and under some circumstances to other animals also.

*Prevailing opinion amongst young chemists.*

It happens that Dr Armsby's book, founded to a great extent on Wolff's earlier editions, was the only work of the kind in the English language; and hence, many of the rising generation of agricultural chemists, both in this country and in America, adopted the view that the albuminoids are the main, if not the exclusive, source of the fat of our farm stock, and of the butter of cows' milk.

Under these circumstances it seemed desirable to consider in some detail, both the experimental evidence bearing upon the question, and the discussions which have taken place in regard to it, during the last quarter of a century or more.

[1] Hermann's *Handbuch d. Physiologie,* Band 6, Theil 1, von C. v. Voit, Leipzig, 1881.

It must be admitted that the importance of the carbohydrates as a direct source of much, if not of the whole, of the fat stored up in the animals which the farmer feeds has been clearly re-established. We have reason to believe that Dr Armsby himself adopts the change of view; though it will probably be some time before the truth is thoroughly recognised by the younger agricultural chemists.

*Armsby's change of opinion.*

It was maintained by Voit and others, that to establish the formation of fat from the carbohydrates, it must be experimentally shown that the fat deposited was in excess of that supplied by the food, *plus* that which could be derived from transformed albumin. But it is obvious that the mere fact that the food contained enough nitrogenous substance for the formation of all the fat that had been produced, would of itself be no proof that that substance had been its source. It has been seen, however, that Voit's requirement was amply fulfilled in the Rothamsted experiments, both with pigs and with sheep; and hence it must be admitted to be proved, that at any rate some of the stored-up fat must have had another source, which could only be the carbohydrates.

*Points proved in Rothamsted experiments.*

In winding up the discussion, perhaps we cannot do better than reiterate the conclusions given in our paper on the subject in 1866, namely:—

*Conclusions.*

1. That certainly a large proportion of the fat of the herbivora fattened for human food must be derived from other substances than fatty matter in the food.

2. That when fattening animals are fed upon their most appropriate food, much of their stored-up fat must be produced from the carbohydrates it supplies.

3. That nitrogenous substance may also serve as a source of fat, more especially when it is in excess, and the supply of available non-nitrogenous constituents is relatively defective.

## Food and Milk Production.

Milk production, and the dairy industry, are of such great and growing importance, and their various branches involve so many points of interest, that much time and space would be required to adequately discuss them. But when considering what are the animal products of value derived from the consumption of food on the farm, it would obviously be inappropriate not to refer, however briefly, to the question of milk production in some of its aspects.

Attention must, however, be confined almost exclusively to the great difference in the demands made on the food—on the one hand for the production of meat, that is of animal in-

crease, and on the other for the production of milk. But, as not only do cows of different breeds yield different quantities of milk, and milk of characteristically different composition, but individual animals of the same breed have very different milk-yielding capacity; and whatever the capacity of a cow may be, she has a maximum yield at one period of her lactation, which is followed by a gradual decline. Hence, in comparing the amounts of constituents stored up in the fattening increase of an ox, with the amounts of the same constituents removed in the milk of a cow, we must assume a wide range of difference in the yield of milk.

*Table 73 explained.*

Accordingly, Table 73 shows—the amounts of nitrogenous substance, of fat, of non-nitrogenous substance not fat, of

TABLE 73.—COMPARISON OF THE CONSTITUENTS OF FOOD CARRIED OFF IN MILK, AND IN THE FATTENING INCREASE OF OXEN.

| [1 Gallon = 10.33 lb.] | Nitrogenous substance. | Fat. | Non-nitrogenous substance not fat (sugar). | Mineral matter. | Total solid matter. |
|---|---|---|---|---|---|
| IN MILK PER WEEK. | | | | | |
| If— | lb. | lb. | lb. | lb. | lb. |
| 4 quarts per head per day | 2.64 | 2.53 | 3.33 | 0.54 | 9.04 |
| 6 " " " | 3.96 | 3 80 | 4.99 | 0.81 | 13.56 |
| 8 " " " | 5.28 | 5.06 | 6.66 | 1.08 | 18.08 |
| 10 " " " | 6.60 | 6.33 | 8.32 | 1.35 | 22.60 |
| 12 " " " | 7.92 | 7.59 | 9.99 | 1.62 | 27.12 |
| 14 " " " | 9.24 | 8.86 | 11.65 | 1.89 | 31.64 |
| 16 " " " | 10.56 | 10.12 | 13.32 | 2.16 | 36.16 |
| 18 " " " | 11.88 | 11.39 | 14.98 | 2.43 | 40.68 |
| 20 " " " | 13.20 | 12.65 | 16.65 | 2.70 | 45.20 |
| IN INCREASE IN LIVE-WEIGHT PER WEEK.—OXEN. | | | | | |
| If 10 lb. increase . . | 0.75 | 6.35 | ... | 0 15 | 7.25 |
| If 15 lb. increase . . | 1.13 | 9.53 | ... | 0.22 | 10.88 |

mineral matter, and of total solid matter, carried off in the weekly yield of milk of a cow, on the alternative assumptions of a produce of—4, 6, 8, 10, 12, 14, 16, 18, or 20 quarts per head per day; and, for comparison, there is given at the bottom of the table, the amounts of nitrogenous substance, of fat, of mineral matter, and of total solid matter, in the weekly increase in live-weight of a fattening ox, of an average weight of 1000 lb.—first, on the assumption of a weekly increase of 10 lb., and, secondly, of 15 lb.

*Percentage constituents of milk.*

The estimates of the amounts of constituents in the milk are based on the assumption that it will contain 12.5 per cent of total solids, consisting of 3.65 albuminoids, 3.50

butter-fat, 4.60 sugar, and 0.75 of mineral matter. The estimates of the constituents in the fattening increase of oxen are founded on the determinations at Rothamsted of such increase as already described.

*Varying yields of milk.*

Referring to the very wide range of yield of milk per head per day which the figures in the table assume, it may be remarked that it is by no means impossible that the same animal might yield the largest amount—namely, 20 quarts, or 5 gallons, per day—near the beginning, and only 4 quarts, or 1 gallon, or even less, towards the end of her period of lactation. At the same time, an entire herd of, say, Shorthorns or Ayrshires, of fairly average quality, well fed, and including animals at various periods of lactation, should not yield an average of less than 8 quarts, or 2 gallons, and would seldom exceed 10 quarts, or 2½ gallons, per head per day, the year round.

*Basis of comparison.*

For the sake of illustration, then, let us assume an average yield of milk of 10 quarts, equal 2½ gallons, or between 25 and 26 lb. per head per day; and let us compare the amount of constituents in the weekly yield at this rate with that in the weekly increase of the fattening ox at the higher rate assumed in the table—namely, 15 lb. per 1000 live-weight, or 1.5 per cent per week.

*Substances carried off in milk and required for fattening.*

Thus, whilst of the nitrogenous substance of the food the amount stored up in the fattening increase of an ox will be only 1.13 lb., the amount carried off as such in the milk would be 6.6 lb., or nearly six times as much. Of mineral matter, again, whilst the fattening increase would only require about 0.22 lb., the milk would carry off 1.35 lb., or, again, about six times as much. Of fat, however, whilst the fattening increase would contain 9.53 lb., the milk would contain only 6.33 lb., or only about two-thirds as much. On the other hand, whilst the fattening increase contains no other non-nitrogenous substance than fat, the milk would carry off 8.32 lb. in the form of milk-sugar. It may be observed that this amount of milk-sugar reckoned as fat would correspond approximately to the difference between the fat in the milk and that in the fattening increase.

*Greater drain upon food by milk than by meat production.*

From the foregoing comparison, it is evident that the drain upon the food is very much greater for the production of milk than for that of meat. This is especially the case in the important item of nitrogenous substance; and if, as is frequently assumed, the butter-fat of the milk is, at any rate largely derived from the nitrogenous substance of the food, so far as it is so, at least about two parts of such substance would be required to produce one of fat. On such an assumption, therefore, the drain upon the nitrogenous substance of the

food would be very much greater than that indicated in the table as existing as nitrogenous substance in the milk. To this point further reference will be made presently.

*Table 74 explained.*

We will next call attention to the amounts of food, and of certain of its constituents, consumed for the production of a given amount of milk. This point is illustrated in Table 74, which shows the constituents consumed per 1000 lb. live-weight per day, in the case of the Rothamsted herd, then of 30 cows, in the spring of 1884.

TABLE 74.—CONSTITUENTS CONSUMED PER 1000 LB. LIVE-WEIGHT PER DAY, FOR SUSTENANCE AND FOR MILK PRODUCTION. THE ROTHAMSTED HERD OF 30 COWS, SPRING 1884.

| | Total dry substance. | Digestible. | | |
|---|---|---|---|---|
| | | Nitrogenous substance. | Non-nitrogenous substance (as starch). | Total nit. and non-nit. substance. |
| | lb. | lb. | lb. | lb. |
| 3.1 lb. Cotton-cake . . . | 2.76 | 1.07 | 1.50 | 2.57 |
| 2.7 lb. Bran . . . . . | 2.33 | 0.33 | 1.09 | 1.42 |
| 2.8 lb. Hay-chaff . . . . | 2.34 | 0.15 | 1.18 | 1.33 |
| 5.6 lb. Oat-straw-chaff . . | 4.64 | 0.08 | 2.21 | 2.29 |
| 62.8 lb. Mangels . . . . | 7.85 | 1.01 | 5.73 | 6.74 |
| Total . . | 19.92 | 2.64[1] | 11.71[1] | 14.35 |
| Required for sustenance . | ... | 0.57 | 7.40 | 7.97 |
| Available for milk . | ... | 2.07 | 4.31 | 6.38 |
| In 23.3 lb. milk . . . | ... | 0.85 | 3.02 | 3.87 |
| Excess in food . . | ... | 1.22 | 1.29 | 2.51 |
| PER 1000 lb. LIVE-WEIGHT. | | | | |
| | lb. | lb. | lb. | lb. |
| Wolff. . | 24 | 2.5 | 12.5[2] | 15.4 |

[1] Albuminoid ratio 1—4.4.

[2] Exclusive of 0.4 fat; albuminoid ratio 1—5.4.

On the left hand are shown the actual amounts of the different foods consumed per 1000 lb. live-weight per day; and in the respective columns are recorded—first the amounts of total dry substance which the foods contained, and then the amounts of digestible nitrogenous, digestible non-nitrogenous (reckoned as starch), and digestible total organic substance, which the different foods would supply; these being calculated according to our own estimates of the percentage composition of the foods, and to Wolff's estimates of the proportion of the several constituents which would be digestible.

*Food consumed per 1000 lb. live-weight.* The first column shows, that the amount of total dry substance of food actually consumed by the herd, per 1000 lb. live-weight, per day, was scarcely 20 lb., whilst Wolff's[1] estimated requirement, as stated at the foot of the table, is 24 lb. But his ration would doubtless consist in larger proportion of hay and straw-chaff, containing a larger proportion of indigestible and effete woody-fibre. The figures show, indeed, that the Rothamsted ration supplied, though nearly the same, even a somewhat less amount of total digestible constituents than Wolff's.

*Consumption of nitrogenous matter for sustenance and milk-production.* Of digestible nitrogenous substance, the food supplied 2.64 lb. per day, whilst the amount estimated to be required for sustenance merely is 0.57 lb.; leaving, therefore, 2.07 lb. available for milk-production. The 23.3 lb. of milk yielded per 1000 lb. live-weight per day would, however, contain only 0.85 lb.; and there would thus remain an apparent excess of 1.22 lb. of digestible nitrogenous substance in the food supplied. But, against the amount of 2.64 lb. actually consumed, Wolff's estimate of the amount required for sustenance and for milk-production is 2.5 lb., or but little less than the amount actually consumed at Rothamsted. On the assumption that the expenditure of nitrogenous substance in the production of milk is only in the formation of the nitrogenous substances of the milk, there would appear to have been a considerable excess given in the food.

*Wolff's estimate.*

*Is milk-fat derived from albuminoids or carbohydrates, or both?* But Wolff's estimate assumes no excess of supply, and that the whole is utilised; the fact being that he supposes the butter-fat of the milk to have been derived largely, if not wholly, from the albuminoids of the food.

It has been shown that although it is possible that some of the fat of a fattening animal may be produced from the albuminoids of the food, certainly the greater part of it, if not the whole, is derived from the carbohydrates. But the physiological conditions of the production of milk are so different from those for the production of fattening increase, that it is not admissible to judge of the sources of the fat of the one from what may be established in regard to the other. It has been assumed, however, by those who maintain that the fat of the fattening animal was formed from albuminoids, that the fat of milk must be formed in the same way. Disallowing the legitimacy of such a deduction, there do, nevertheless, seem to be reasons for supposing that the fat of milk may, at any rate in large proportion, be derived from albuminoids.

Thus, as compared with fattening increase, which may in

[1] *Landw. Futterungslehre*, 5te Aufl., 1888, p. 249.

a sense be said to be little more than an accumulation of reserve material from excess of food, milk is a special product of a special gland, for a special normal exigency of the animal. Further, whilst common experience shows that the herbivorous animal becomes the more fat, the more, within certain limits, its food is rich in carbohydrates, it points to the conclusion that both the yield of milk, and its richness in butter, are more connected with a liberal supply of the nitrogenous constituents in the food. Obviously, so far as this is the case, it may be only that thereby more active change in the system, and therefore greater activity of the special function, is maintained. The evidence at command is, at any rate, not inconsistent with the supposition that a good deal of the fat of milk may have its source in the breaking up of albuminoids, but direct evidence on the point is still wanting; and, supposing such breaking up to take place in the gland, the question arises — what becomes of the bye-products? Assuming, however, that such change does take place, the amount of nitrogenous substance supplied to the Rothamsted cows would be less in excess of the direct requirement for milk-production than the figures in the table would indicate—if, indeed, in excess at all.

*Milk-production more dependent than meat-production upon nitrogenous substances.*

The figures in the column relating to the estimated amount of digestible non-nitrogenous substance reckoned as starch, show that the quantity actually consumed was 11.71 lb., whilst the amount estimated by Wolff to be required was 12.5 lb., besides 0.4 lb. of fat. The figures further show that, deducting 7.4 lb. for sustenance from the quantity actually consumed, there would remain 4.31 lb. available for milk-production, whilst only about 3.02 would be required supposing that both the fat of the milk and the sugar had been derived from the carbohydrates of the food; and, according to this calculation, there would still be an excess in the daily food of 1.29 lb.

*Non-nitrogenous matter for sustenance and milk-production.*

It is to be borne in mind, however, that estimates of the requirement for mere sustenance are mainly founded on the results of experiments, in which the animals are allowed only such a limited amount of food as will maintain them without either loss or gain when at rest. But physiological considerations point to the conclusion that the expenditure, independently of loss or gain, will be the greater the more liberal the ration; and hence it is probable that the real excess, if any, over that required for sustenance and milk-production, would be less than that indicated in the table, which is calculated on the assumption of a fixed requirement for sustenance for a given live-weight of the animal.

*Variations in food requirements for sustenance.*

Supposing that there really was any material excess of

*Excess of food supply and its destination.*

either the nitrogenous or the non-nitrogenous constituents supplied over the requirement for sustenance and milk-production, the question arises—Whether, or to what extent, it conduced to increase in live-weight of the animals, or whether it was in part or wholly voided and so wasted?

It would obviously be of interest to trace the connection between variation in the quantity and composition of the food, and the quantity and composition of the milk yielded. But when the influence on the result, of breed, of varying character of individual animals, of period of lactation, and of other circumstances, are borne in mind, it will be seen that to treat the subject at all adequately would involve a great deal of detailed illustration and consideration, and occupy very much more space than could appropriately be devoted to it in this place. We must, indeed, limit further reference to the subject of milk-production to one more illustration, showing the influence of period of the year, with its characteristic changes of food, on the quantity and composition of the milk.

The first column of the second division of Table 75 shows the average yield of milk per head per day of the Rotham-

TABLE 75.—Percentage Composition of Milk each month of the year; also Average yield of Milk, and of Constituents, per head per day, each month, according to Rothamsted Dairy Records.

| | Average composition of milk each month, 1884 (Dr Vieth—14,235 analyses). | | | | Rothamsted Dairy. | | | |
|---|---|---|---|---|---|---|---|---|
| | Specific gravity. | Per cent. | | | Average yield of milk per head per day, 6 years. | Estimated quantity of constituents in milk per head per day each month. | | |
| | | Butter-fat. | Solids not fat. | Total solids. | | Butter-fat. | Solids not fat. | Total solids. |
| | | Per cent. | Per cent. | Per cent. | lb. | lb. | lb. | lb. |
| January | 1.0325 | 3.55 | 9.34 | 12.89 | 20.31[1] | 0.72 | 1.90 | 2.62 |
| February | 1.0325 | 3.53 | 9.24 | 12.77 | 22.81 | 0.80 | 2.11 | 2.91 |
| March | 1.0323 | 3.50 | 9.22 | 12.72 | 24.19 | 0.85 | 2.23 | 3.08 |
| April | 1.0323 | 3.43 | 9.22 | 12.65 | 26.50 | 0.91 | 2.44 | 3.35 |
| May | 1.0324 | 3.34 | 9.30 | 12.64 | 31.31 | 1.05 | 2.91 | 3.96 |
| June | 1.0323 | 3.31 | 9.19 | 12.50 | 30.81 | 1.02 | 2.83 | 3.85 |
| July | 1.0319 | 3.47 | 9.13 | 12.60 | 28.00 | 0.97 | 2.56 | 3.53 |
| August | 1.0318 | 3.87 | 9.08 | 12.95 | 25.00 | 0.97 | 2.27 | 3.24 |
| September | 1.0321 | 4.11 | 9.17 | 13.28 | 22.94 | 0.94 | 2.11 | 3.05 |
| October | 1.0324 | 4.26 | 9.27 | 13.53 | 21.00 | 0.89 | 1.95 | 2.84 |
| November | 1.0324 | 4.36 | 9.29 | 13.65 | 19.19 | 0.84 | 1.78 | 2.62 |
| December | 1.0326 | 4.10 | 9.29 | 13.39 | 19.31 | 0.79 | 1.79 | 2.58 |
| Mean | 1.0323 | 3.74 | 9.22 | 12.96 | 24.28 | 0.90 | 2.24 | 3.14 |

[1] Average over 5 years only, as the records did not commence until February 1884.

sted herd, averaging about 42 cows, almost exclusively Shorthorns, in each month of the year, over six years, 1884-1889 inclusive; and the succeeding columns show the amounts of butter-fat, of solids not fat, and of total solids, in the average yield per head per day in each month of the year, calculated, not according to direct analytical determinations made at Rothamsted, but according to the results of more than 14,000 analyses made under the superintendence of Dr Vieth, in the laboratory of the Aylesbury Dairy Company, in 1884;[1] the samples analysed representing the milk from a great many different farms in each month.

*Period of year and yield and quality of milk.*

It should be stated that the Rothamsted cows had cake throughout the year; at first 4 lb. per head per day, but afterwards graduated according to the yield of milk, on the basis of 4 lb. for a yield of 28 lb. of milk, the result being that then the amount given averaged more per head per day during the grazing period, but less earlier and later in the year. Bran, hay, and straw-chaff, and roots (generally mangels), were also given when the animals were not turned out to grass. The general plan was, therefore, to give cake alone in addition, when the cows were turned out to grass, but some other dry food, and roots, when entirely in the shed during the winter and early spring months.

*Food allowed.*

Referring to the column showing the average yield of milk per head per day each month over the six years, it will be seen that during the six months—January, February, September, October, November, and December — the average yield was sometimes below 20 lb., and on the average, only about 21 lb. of milk per head per day; whilst over the other six months it averaged 27.63 lb., and over May and June more than 31 lb., per head per day. That is to say, the quantity of milk yielded was considerably greater during the grazing period than when the animals had more dry food, and roots instead of grass.

*Greater yield of milk in summer than winter.*

Next referring to the particulars of composition, according to Dr Vieth's results, which may well be considered as typical for the different periods of the year, it is seen that the specific gravity of the milk was only average, or lower than average, during the grazing period, but rather higher in the earlier and later months of the year. The percentage of total solids was rather lower than the average at the beginning of the year, lowest during the chief grazing months, but considerably higher in the later months of the year, when the animals were kept in the shed, and received more dry food. The percentage of butter-fat follows very closely that of the total solids,

*Variations in composition of milk at different seasons.*

[1] *The Analyst*, April 1885, vol. x. p. 67.

being the lowest during the best grazing months, but considerably higher than the average during the last four or five months of the year, when more dry food was given. The percentage of solids not fat was considerably the lowest during the later months of the grazing period, but average, or higher than average, during the earlier and later months of the year.

It may be observed that, according to the average percentages given in the table, a gallon of milk will contain more of both total solids and of butter-fat in the later months of the year; that is, when there is less grass and more dry food given.

*Variations in quantities of different constituents per head per day.*

Turning now to the last three columns of the table, it is seen that although, as has been shown, the percentage of the several constituents in the milk is lower during the grazing months, the actual amounts contained in the quantity of milk yielded per head, are distinctly greater during those months. Thus, the amount of butter-fat yielded *per head per day* is above the average of the year from April to September inclusive; the amounts of solids not fat are over average from April to August inclusive; and the amounts of total solids yielded are average or over average from April to August inclusive.

*Yield of milk in summer greater in quantity but poorer in quality than in winter.*

From the foregoing results, it cannot be doubted that the quantity of milk yielded per head is very much the greater during the grazing months of the year; but that the percentage composition of the milk is lower during that period of higher yield, and considerably higher during the months of more exclusively dry-food feeding. Nevertheless, owing to the much greater quantity of milk yielded during the grazing months, the actual quantity of constituents yielded per cow is greater during those months than during the months of higher percentage composition, but lower yield of milk per head. It may be added, that a careful consideration of the number of newly calved cows brought into the herd each month shows that the results as above stated were perfectly distinct, independently of any influence of the period of lactation of the different individuals of the herd.

*Further investigation required.*

The few results which have been brought forward in relation to *Milk-production* are admittedly quite insufficient adequately to illustrate the influence of variation in the quantity and composition of the food, on the quantity and composition of the milk yielded. Indeed, owing to the intrinsic difficulties of experimenting on such a subject, involving, as has been pointed out, so many elements of variation beside those which it is sought to investigate, any results obtained have to be interpreted with much care and reservation. Nevertheless,

exercising such care and reservation in regard to the numerous results of ourselves and others which are at command, it may be taken as clearly indicated that, within certain limits, high feeding, and especially high nitrogenous feeding, does increase both the yield and the richness of the milk. But it is evident that, when high feeding is pushed beyond a comparatively limited range, the tendency is to increase the weight of the animal—that is, to favour the development of the individual, rather than to enhance the activity of the functions connected with the reproductive system. This is, of course, a disadvantage when the object is to maintain the milk-yielding condition of the animal; but when a cow is to be fattened off it will be otherwise.

*High feeding and yield of milk.*

It has been stated that, early in the period of six years in which the Rothamsted results that have been quoted were obtained, the amount of oil-cake given was graduated according to the yield of milk of each individual cow; as it seemed unreasonable that an animal yielding, say, only 4 quarts per head per day, should receive, beside the home foods, as much cake as one yielding several times as much. The obvious supposition is, that any excess of food beyond that required for sustenance and milk-production would tend to increase the weight of the animal, which, according to the circumstances, may or may not be desirable. But there remains the important question—Whether the period of lactation is lengthened, or the yield of the higher yielding cows is maintained the longer, by an increased amount of food; or whether, on the other hand, the period of lactation, or the yield of milk, is reduced by the limitation of the supply of food? The point is, at any rate, deserving of careful experiment and observation.

*Food allowance graduated according to yield of milk.*

It may be observed that direct experiments at Rothamsted confirm the view, arrived at by common experience, that roots, and especially mangels, have a favourable effect on the flow of milk. Further, the Rothamsted experiments have shown that a higher percentage of butter-fat, of other solids, and of total solids, was obtained with mangels than with silage as the succulent food. The yield of milk was, however, in a much greater degree increased by grazing than by any other change in the food; and with us, at any rate, the influence of roots comes next in order to that of grass, though far behind it, in this respect. But, with grazing, as has been shown, the percentage composition of the milk is considerably reduced; though, owing to the greatly increased quantity yielded, the amount of constituents removed in the milk whilst grazing may, nevertheless, be greater per head per day than under any other conditions.

*Influence of different foods on yield of milk.*

Lastly, it has been clearly illustrated how very much greater is the demand upon the food, especially for nitrogenous and for mineral constituents, in the production of milk than in that of fattening increase.

## FOOD AND MANURE.

At the commencement of this Section on the Feeding of Animals, it was shown, by reference to a special example, how large was the proportion of the constituents of the crops grown in a rotation which was retained on the farm for further use—in fact, for consumption by animals, or for litter.

*Constituents of crops retained on farms.*

It was shown that, in the case selected for illustration, there would be so retained on the farm for such further use, more than two-thirds of the total vegetable substance grown, more than half of the nitrogen of the crops, and about six-sevenths of the total mineral matter; whilst, of the individual mineral constituents of the crops, less than half of the phosphoric acid, but about four-fifths of the potash, would be retained.

Of course, in the very varied practice of Agriculture at the present day, there will sometimes be larger, and sometimes smaller, proportions of the various constituents of the crops at once sold off, or retained on the farm; but the example given may be taken as essentially typical, and as so far conveying a very useful impression on the subject. But, besides the constituents of the home-grown rotation crops retained upon the farm for food and litter, there will be more or less produce from grass land, whilst modern practices frequently involve the purchase of a considerable quantity of imported food-stuffs.

*Feeding as a source of manure.*

Results relating to the feeding of animals for the production of meat, and of milk, have been considered; and we have now to discuss the subject of feeding as a source of manure. Numerous Rothamsted experiments have shown how small is the proportion of the various constituents consumed in food by fattening, or even by growing animals, which is stored up in their increase, and which will therefore be lost to the manure. In the production of milk, however, it has been seen that the loss to the manure is very much greater.

Of the mineral matters of the food, we know that there need be no loss to the manure beyond that carried off in the animal increase or in milk. Of the non-nitrogenous organic substance of the food, a very large proportion is lost by the respiration of the animals, and a not inconsiderable quantity contributes to the animal increase or milk; and what remains for manure is of no material value as a direct supply of con-

stituents, and of comparatively little by the action of its products of decomposition within the soil. Indeed, the most important point to consider is—what proportion of the *nitrogen* of the food remains for manure? As has been shown, and as will be further illustrated presently, only a comparatively small proportion is carried off in animal increase; but a much larger amount is lost to the manure in the production of milk. But the further questions arise—Is there any, so to speak, vital exhalation of nitrogen, or of any compounds of it, by the animal? Or, may we estimate that the whole of that consumed which is not carried off in the animal increase, or in milk, will be found in the solid and liquid dejections, and so remain for manure? Or, on the other hand, is there any assimilation by the animal, of the free nitrogen of the atmosphere? The further practical question still remains—Is there any material loss of nitrogen after the solid and liquid excretions leave the body, and before their utilisation within the soil for the production of future crops?

*What proportion of nitrogen in food remains for manure?*

First, then, is there any vital exhalation by the animal of nitrogen or of any of its compounds?

*Exhalation and absorption of nitrogen by animals.*

Obviously, this is a question which could not be experimentally investigated before definite knowledge was attained in regard to the composition of the atmosphere. But after such knowledge had been acquired, rather more than a century ago, the subject of the mutual relations of the atmosphere, and of vegetable and animal growth, came to be studied; and, among other points, it was sought to determine whether, on the one hand, the free nitrogen was assimilated by animals? or, on the other, whether it was exhaled, at the expense of the nitrogenous substance of the food, of the blood, or of the more fixed substance of the body?

Commencing towards the end of the last century, numerous investigations have been undertaken from various points of view bearing upon the subject; and among the investigators or writers may be named—Lavoisier, Laplace, Séguin, Dalton, Sir H. Davy, Pfaff, Provençal and Humboldt, Allen and Pepys, Despretz and Dulong, Brunner and Valentin, Marchand, von Erlach, Baumert, Regnault and Reiset, Berthollet, Milne-Edwards, and C. G. Lehmann; besides others more recently.

*Various investigations.*

It is impossible shortly, and at the same time adequately, either to describe or to criticise the numerous and, upon the whole, discordant results, that have been obtained in regard to the question of the assimilation or exhalation of free nitrogen by animals. It is noticeable that the earlier investigators, Lavoisier, Laplace, and Séguin, concluded that the amount of nitrogen expired was neither more nor less than

that inspired; and in this view they are in the main supported by the conclusions, though not entirely by the results, of Allen and Pepys, of Brunner and Valentin, and von Erlach. In favour of the view that free nitrogen is absorbed and assimilated, may be cited the opinions of Sir Humphrey Davy and of Pfaff, so far as certain warm-blooded animals are concerned; and of Provençal and Humboldt, and of Baumert, in regard to fish. On the other hand, that there is evolution of free nitrogen has been concluded, by Sir H. Davy, Berthollet, Dulong and Despretz, Magnus, Marchand, Grassi, Regnault and Reiset, and C. G. Lehmann.

In regard to evolution, the most extensive and elaborate experiments are those of Regnault and Reiset. But the amounts which their results indicated would imply the loss, in that way, of an incredibly large proportion of the total nitrogen consumed in the food; whilst Liebig estimated that the evolution which Dulong assumed was so great that, in the case of one of the experimental animals, the whole of the nitrogen of the body would be lost in seven days; and that, at the rate assumed by Despretz, the nitrogen of one pound of flesh would go off in thirty-one hours.

Then, the results indicating absorption are the most pronounced in the experiments with fish. The question arises, therefore, whether in their case the result may not be explained by supposing that oxygen has been absorbed from the air within the body, especially in the swimming bladder, and nitrogen stored up in its place, under the conditions of limited supply of oxygen from external sources to which the animals have generally been subjected during experiment.

*Investigations not conclusive.*

Upon the whole it must be concluded that, from a variety of causes, connected sometimes with the conditions under which the animals were placed under experiment, sometimes with the circumstances under which the samples assumed to represent the inspired and expired air, respectively, were taken for analysis, and sometimes with the methods of analysis themselves, the results of the experiments on respiration which have been referred to, have not been sufficiently free from doubt to be accepted as establishing so important a conclusion as either the assimilation of free nitrogen by animals, or the evolution of it from its compounds within the body.

*Loss of nitrogen in breathing and sweating.*

The next point to consider is—whether there is any loss of ammonia, or of other compounds of nitrogen, in the breath, or by the skin.

Louis Thompson, Thiry, Grouven, and others, have found some emanation of ammonia; but Lossen, and others, consider it doubtful whether the ammonia in the air itself might not account for the results.

Various experiments have been made to determine the loss of nitrogen in sweat. In the sweat of man ammonia and urea have been found. In the sweat of a horse Grandeau and Leclerc[1] found ammonia, urea, and albumin. Professor F. Smith, of Aldershot,[2] has also examined the sweat of horses. Besides various inorganic salts, he found ammonia, and 3.381 per cent of albumin. He reckons that a pint of sweat will thus contain 0.676 ounce of albumin, and that this amount would be equivalent to the nitrogen in 5¾ ounces of oats. He further thinks it probable that the reduction of sweating by clipping would, with hard work, be equivalent to 1 lb. of corn per day.

*Loss immaterial.* It seems safe to conclude that the loss of combined nitrogen by gaseous emanations from the lungs and skin is, for all practical purposes, quantitatively immaterial The sweat would seem to be a more important source of loss in animals submitted to much muscular exercise. But, even in their case, it does not seem to be large; whilst in that of the animals of the farm fed for the production of meat or milk, it would presumably be much less material.

*Amounts of nitrogen in food and manure.* We now come to the consideration of evidence of quite another kind as to the loss to the manure of the nitrogen of the food, beyond the amount stored up in increase, or removed in milk: namely, that afforded by the results of experiments made to determine the relation of the amount of nitrogen voided in the solid and liquid excretions, to that consumed in the food. Most of these have been made with the animals of the farm; indeed, most of them have had for their object the direct determination of the amount of the nitrogen of the food consumed which is recovered in the manure in practical feeding. The chief results may be very briefly summarised as follows:—

*Boussingault's experiments.* Boussingault made experiments[3] with a cow, with a horse, and with turtle-doves (probably between 1830 and 1840).

In the experiment with a cow, the animal was fed on the same food for about a month, and the results relate to the three concluding days of that period. Boussingault observes that the animal did not suffer any material change in weight. Besides the nitrogen removed in the milk, there was an amount not recovered in the excrements which represented a loss of 13.4 per cent of the total nitrogen of the food.

In the experiment with a horse, the animal had received

[1] *Annales de la Science agronomique*, 5[me] *année*, 1888, tome ii. pp. 311-314.
[2] *Journal of Physiology*, 1890, vol. xi. p. 497.
[3] *Agronomie, Chimie agricole et Physiologie*, 2[me] ed., 1874, vol. v. p. 144.

*Nitrogen not accounted for.* the same ration for three months, and did not either gain or lose in weight appreciably. There was here again an amount unaccounted for, representing a loss of 17.2 per cent of the nitrogen of the food.

In the two experiments with turtle-doves, one over five and the other over seven days, each of the birds rather lost weight. Their food was millet; and in the one case there was a loss of 35.9, and in the other of 34.1, per cent of the nitrogen in the food. Boussingault thought that there was undoubtedly a loss of nitrogen, as the amount unrecovered was far too great to be accounted for by errors of analysis.

*Experiments at Rothamsted; how conducted.* Experiments were made on the subject at Rothamsted in 1854 with pigs. Individual male animals were experimented upon, for periods of three and of ten days. Each animal was kept in a frame, preventing it from turning round, and having a zinc bottom sloping slightly from each side towards the centre, where there was an outlet for the urine to run into a bottle beneath. They were watched night and day, and the voidings carefully collected as soon as passed, which could easily be done, as the animals never passed either fæces or urine without getting up, and in so doing rang a bell, and thus attracted the notice of the attendant. The constituents determined were—in the food and fæces, dry matter, ash, and nitrogen; and in the urine, dry matter, ash, nitrogen, and urea. In preparing samples of fæces or of urine for nitrogen determinations, a mixture was made of a proportional part of the voiding of each twenty-four hours, and oxalic acid added. In the case of the fæces, portions of the acid mixture were taken for the determination of dry matter; and nitrogen determinations were made in the partially dried substance, and calculated up to the fully dried condition. In the case of the urine, portions of the acid mixture were fully dried, and other portions partially dried, and then mixed with about half the weight of fully dried oak-dust, in which the nitrogen was determined.

*Food used. Nitrogen consumed and voided.* Over a preliminary period, and also over each period of exact experiment, one animal received the highly nitrogenous lentil-meal, and the other the low-in-nitrogen barley-meal. In each case, the one receiving lentil-meal consumed more than twice as much nitrogen in food, and voided more than twice as much in the solid and liquid excrements.

*Nitrogen not accounted for.* Notwithstanding the great attention paid to the collection, the sampling, and the preparation of the samples of the excrements for nitrogen determinations, as above described, there was, in each case, a considerable amount of the nitrogen of the food unaccounted for in that estimated in the increase

and in that found in the excrements. There was, too, a much greater loss indicated by the results of the direct nitrogen determinations in the urine dried with an excess of oxalic acid, than when the nitrogen was calculated from the amount of urea found daily in the fresh urine. As, however, nitrogen determinations (by soda-lime and platinum salt) were made by two analysts, whose results agreed very fairly, it may be concluded that the loss was connected with the methods of collection, sampling, and preparation for analysis, rather than with those of the analysis; and it is probable that the same remark applies to the results obtained with the fæces. In illustration of the range of loss of nitrogen indicated, it may be stated that when the nitrogen in the urine was reckoned from the amount of urea, the loss ranged in the four experiments between 20 and 30 per cent of that in the food, and when by direct nitrogen determinations in urine as well as in fæces, from under to over 40 per cent. However, in the case of each food, whether the nitrogen in the urine was determined, or calculated from the urea, there was considerably less loss indicated over the ten-day than over the shorter three-day period; again connecting the error with the collection, sampling, and preparation, rather than with the analysis.

*Further experiments made.*

In view of these unsatisfactory results, and of the evidence that much at any rate of the loss was probably due to experimental difficulties and errors, the subject was taken up again in 1862. The pigs were kept in frames as before, and the voidings were collected in the same way; but they were sampled morning and evening, instead of only once in the twenty-four hours, as in 1854. Advantage was also taken of the previous experience in regard to various other points of manipulation. Lastly, the direct nitrogen determinations were made by soda-lime as before, but with titration instead of platinum salt.

*Food used.*

Two animals were experimented upon, each for a period of ten days, and after an interval of a few weeks for five days more. The food of one consisted of three parts bean-meal and one part bran, and of the other of three parts barley-meal and one part bran.

*Nitrogen accounted for and not accounted for.*

In the case of the pig having the highly nitrogenous bean-meal and bran, the nitrogen balance for the ten days showed a gain of 4.04 per cent when direct nitrogen determinations were made in the urine, and of only 2.32 per cent when the nitrogen in the urine was calculated from the amount of urea. On the other hand, over the five-day period there was a loss indicated of 3.35 per cent with the direct nitrogen determinations in the urine, and of only 1.61 per cent when the nitrogen was calculated from urea. In the latter case, therefore, the

amount of nitrogen accounted for was again less with direct determination than by calculation from urea.

In the case of the pig having the low-in-nitrogen barley-meal and bran, there was, over the ten-day period, a loss indicated of 7.16 per cent of nitrogen with direct determination, and of only 4.90 per cent when the nitrogen was calculated from the urea. In this case, therefore, there was again less loss of nitrogen by calculation from urea than by direct determination. Lastly, over the five-day period there was, with the barley-meal and bran, a gain of nitrogen indicated of 7.76 per cent with direct determination of nitrogen in the urine, and of 11.02 per cent when calculated from the urea. In both cases, therefore, there was more nitrogen accounted for by calculation from urea than by direct determination.

These results obtained in 1862 show, therefore, with the beans and bran, a slight gain over the ten days, and a slight loss over the five days. On the other hand, with the barley and bran there was a comparatively small loss over the ten days, and a somewhat greater gain over the five days.

*No real loss of nitrogen.*

When the fact that there was a much greater variation in the amounts of the daily voidings than in those of the food daily consumed, and also the uncertainty in the estimation of the proper increase of the animals over short periods and of the nitrogen in it, are taken into account, these results must be admitted to afford no evidence of any real loss to the manure of the nitrogen of the food beyond that in the increase and in the excrements.

*Experiments with sheep.*

The next results to consider were obtained at Rothamsted in 1861 with sheep. There were four pens with five sheep in each. Besides the determination of the total dry matter, ash, and nitrogen, in the food and in the excrements, one special object was to determine what proportion of the cellulose of the food was digested, and whether more or less was so utilised according to the character of the foods given with it. Accordingly, foods containing a comparatively large amount of cellulose were selected, as under:—

*Food used.*

Pen 1. Meadow hay-chaff alone *ad libitum.*
" 2. 1 lb. of ground beans per head per day, and meadow hay-chaff *ad libitum.*
" 3. 1 lb. of ground barley per head per day, and meadow hay-chaff *ad libitum.*
" 4. About 6½ oz. of ground beans, and about 3½ oz. of linseed-oil, per head per day, and meadow hay-chaff *ad libitum.*

In Pen 4 the object was to give an amount of beans containing the same quantity of nitrogen as the barley of Pen 3, and then to make up the deficiency of starch in the smaller

quantity of beans compared with that in the barley by oil, in the proportion of 1 part of oil for 2½ parts of starch.

With a view to the careful collection, sampling, and analysis, of the excrements, the sheep were kept under cover, on rafters, through which (but with some loss) the solid and liquid excreta passed on to a sheet-zinc flooring, at such an incline that the liquid drained off at once into carboys containing oxalic acid; and the solid matter was removed two or three times daily, and also mixed with oxalic acid.

After a preliminary period of eight weeks the exact feeding experiment was continued for thirty-two weeks more—from January 25 to September 6. Commencing on March 26, and ending on August 9, samples of the excrements were taken at intervals, in each case for several consecutive days—namely, 4, 5, 5, 7, 7, 7, 7, 7, 7, and 7 days; and the results here given are the means of the seven 7-day periods. The amounts of nitrogen so indicated to be not recovered in either the increase or in the excreted matters were, in the four pens, respectively 12.5, 25.4, 15.2, and 17.7 per cent of the nitrogen supplied in the food. It is to be observed that the estimated loss is the greatest with the most, and the least with the least, nitrogen in the food. The question arises—Whether the greater estimated loss is connected with an under-estimate of the nitrogen in the increase of the animals feeding on the more highly nitrogenous food, or with an actually greater loss from decomposition in the case of the more highly nitrogenous excrements.

*Nitrogen not accounted for.*

In 1858, Henneberg[1] made experiments with two oxen, each separately. The animals were kept on sustenance food only. After a preliminary period of several weeks, there were three periods of more exact experiment—the first from February 27 to March 27, the second from March 28 to May 21, and the third from May 22 to July 15; and during three days towards the end of each of these periods the excrements were collected and analysed. Ox No. 1 gained 6 lb. during the three days of the first period, 1 lb. during those of the second, and 11 lb. during those of the third. The percentage of the nitrogen of the food which was not recovered in the excrements was, for the respective three-day periods, 5.7, 28.8, and 15.1, or an average of 16.5. Ox No. 2 neither gained nor lost during the first three-day period, lost 3 lb. during the second, and 8 lb. during the third; and the analyses of the excrements showed a gain of nitrogen compared with that in the food of 9.6 per cent over the first three days, a loss of 24.7 per cent over the second three, and a gain of 6.3 per cent

*Henneberg's experiments.*

*Nitrogen not accounted for.*

[1] *Beiträge zur Begrundung einer rationellen Futterung der Wiederkäuer*, Heft 1, 1860.

over the third. That is to say, Ox No. 1, with more or less gain over each of the three-day periods—which may perhaps be interpreted as retention in the alimentary canal or bladder rather than increase in the substance of the body—showed a considerable deficit of nitrogen in the excrements compared with that in the food. Ox No. 2, on the other hand, with loss of weight—which probably only represented more complete evacuation in relation to the food consumed—indicated more of tendency to excess of nitrogen in the excrements compared with that in the food. In experiments in 1860-61, also with two bullocks, Henneberg found—this time over six-day instead of three-day periods—deficits of nitrogen in the excrements corresponding to the following percentages of the amounts supplied in the food—35, 37, 21, 12, 10, 0. It may be observed that the percentage of loss was, upon the whole, the greater with the larger amounts of nitrogen in the food. Later results of Henneberg will be referred to further on.

*No litter used.*

In none of the foregoing experiments, either by Boussingault, at Rothamsted, or by Henneberg, was any litter used, the excrements being collected and analysed by themselves.

*Experiments at Woburn Park.*

In 1851, we made experiments with oxen, at Woburn Park Farm, by the permission of the Duke of Bedford. In the experiment, the results of which are given below, there were five Herefords, each in a separate box, and the experimental period extended over thirty-five days. Liberal fattening food was given, consisting of a cooked mixture of equal parts of ground oil-cake, barley, and beans, besides clover-hay-chaff, and swedes. The litter consisted of wheat-straw; and an absorbent, composed of 2 parts sawdust and 1 part sulphuric acid, was used; a small quantity being daily sprinkled over the manure in the boxes just before spreading the fresh litter. At the end of the expeiiment the whole of the dung was got out, put into a large shed, turned over by men, pulled to pieces by boys, and thoroughly mixed; and in that state it was weighed, and several separate 100 lb. samples were taken, each being put into a clean cask, in which state the samples were sent to Rothamsted for analysis. In the preparation for analysis, the whole of the 100 lb. sample was coarsely ground, then divided into portions, one or more of which was finely ground for analysis, and in the sample so prepared the nitrogen was determined by the soda-lime method. It was so determined separately in samples from two of the 100 lb. casks. Deducting the amount of nitrogen in the increase (reckoning it to contain 1.27 per cent), there was a deficiency of nitrogen in the dung, compared with that in the food and litter—according to one

*Nitrogen not accounted for.*

100-lb. sample, of 8.03, and to the other or duplicate one, of 10.55 per cent.

Such, then, were the results of the earlier experiments made by various investigators, to determine whether or not there was any loss of nitrogen in the feeding of animals beyond that stored up in their increase. It will be observed that, with the exception of the turtle-doves experimented upon by Boussingault, all the other results were obtained with the animals of the farm; and in all cases, excepting those of the experiments at Rothamsted with pigs and with sheep, and at Woburn with oxen, the animals were assumed to be fed on only sustenance rations, and no allowance was made in the calculations for any increase or loss in their weight. It has been seen that in every case, excepting in the experiment with Henneberg's Ox No. 2, and in the experiments at Rothamsted with pigs in 1862, the figures indicate a notable, and in some a very considerable, loss of nitrogen; which, assuming it to be not explained by storing up of nitrogen in the animal, or deficient evacuation, might be supposed to point to a probable loss by respiration, or perspiration, or both. *Review of results as to loss of nitrogen.*

From a study in much detail of the direct experiments on respiration and perspiration which have been referred to, we ourselves have been disposed to conclude that there was no material exhalation of either free nitrogen or of its compounds. Further, notwithstanding our own early results with pigs, those with sheep, and those at Woburn with oxen, all indicated more or less, and sometimes a considerable loss, the observations made during the conduct of the investigations so fully impressed us with the liability to error, especially on the side of loss, that we have always considered it doubtful whether there was in reality any material loss at all. In the first place, there is the uncertainty in the estimation of the changes in the weight of the body—whether to attribute them to increase or loss of its fixed substance, or to excess or deficiency in the evacuations in relation to the food consumed within the period of experiment; and there are, besides, great difficulties to be overcome, both in the complete collection, the proper sampling, and the preparation, without change, of the excreted matters; and there are also special difficulties in the adaptation of analytical methods to secure exact representative results. Indeed, most of the results so far quoted, whether of ourselves or others, must be looked upon as little more than pioneer; though, taken as such, the experience gained has proved to be of essential value in directing attention to the difficulties and sources of error incident to such work, and to the improve- *Loss of nitrogen doubtful.*

ment in methods of collection, sampling, preparation, and analysis.

For ourselves, being satisfied that much if not the whole of the losses that had been indicated was to be explained by the methods of experimenting, and being very fully occupied with other subjects, we decided, after our experiments with pigs in 1862, not to devote the very great amount of time and labour that would be involved in the repetition of the investigation with still further precautions.

*Further experiments in Germany.*

In Germany, however, Henneberg and his colleagues (G. Kühn, H. Schultze, and B. Schultz), at Weende, as well as others, continued to work on the subject with the animals of the farm. Henneberg[1] pointed out that the experiments of Bischoff and Voit with dogs in 1859,[2] of Ranke with man in 1860-61,[3] of Voit with pigeons in 1860-62,[4] and of Pettenkofer and Voit with man,[5] showed almost complete re-appearance of the nitrogen of the food in the solid and liquid excretions; and, if this were the case with carnivora and omnivora, there seemed no reason why it should not be so with herbivora. He further pointed out how small an actual loss or gain in the determined amount of nitrogen in the fæces or the urine might make a great difference in the balance; and he admitted that more attention than had hitherto been given to certain points must in future be devoted—as, for instance, to the rinsing and washing of the stalls, and to the determination of the dry matter in the food, fæces, and urine, more frequently and uniformly throughout the experimental period.

In the Weende experiments of 1865, and subsequently, more attention was paid to such points, and the periods of exact experiment were longer. There was, accordingly, great improvement in the results. Thus, in a series of eight experiments with oxen, in five with only sustenance or maintenance rations, the result was that, in three of them the percentage deficit of nitrogen in the excrements compared with that in the food was 0.4, 2.7, and 2.2.; whilst in the other two there was a gain representing 0.8 and 3.7 per cent. In the three other experiments, fattening food containing about twice as much nitrogen was given, and in these the deficits in the excrements were 12.1, 12.0, and 17.7 per cent of the nitrogen in the food. Henneberg concluded that, with only sustenance rations, the whole of the nitrogen of the food of oxen reappeared in the excrements, and that it was no longer

*Nitrogen of the food entirely reappearing in excrements.*

[1] *Neue Beiträge*, Göttingen, i. 373-375, 1872.

[2] *Die Gesetze der Ernahrung des Fleischfressers*, Leipzig, 1860.

[3] *Archiv für anat., phys. und wissenschaftliche Medicin*, Leipzig, 1862, p. 311.

[4] *Annalen*, II. Suppl. p. 238, 1862.

[5] *Zeits. f. Biol.*, II. p. 459.

necessary to infer from the results obtained with other animals what would take place with ruminants.

*Experiments with cows.* Henneberg also quotes results[1] obtained with cows by Voit at Munich, by G. Kuhn and Fleischer at Möckern, and by Fleischer at Hohenheim. Voit's results, obtained in 1867, showed a deficit of nitrogen in the milk, fæces, and urine, representing 1.2 per cent of that in the food. In eight experiments made at Möckern in 1867-68 with cows, six showed respectively losses corresponding to 2.9, 11.1, 3.8, 5.6, 16.4, and 7.0 per cent of the nitrogen in the food; and the other two showed gains corresponding to 1.2 and 4.8 per cent. In the case of the larger losses more nitrogen was consumed in the food, and the animals gained in weight, and presumably stored-up nitrogen. At Hohenheim, in 1870, experiments were made by Fleischer with two cows, one of which showed a loss of 0.3, and the other a gain of 0.6 per cent of nitrogen compared with that in the food.

*Losses and gains of nitrogen.*

Experiments were also made with sheep by Maercker and E. Schulze, at Weende,[2] which confirmed the conclusions drawn from those with oxen and cows as above, as also did others made by Stohmann with goats[3] at the Halle experimental station.

*Trials with dogs.* We will conclude the citation of experimental evidence on the point, by reference to some of the results obtained by Voit from 1859 to 1863 with dogs.[4] In none of these cases was the period of exact experiment less than 6 days, whilst in some it was 12, 14, 20, 23, 49, and even 58 days. In eight out of the eleven cases there was an excess of nitrogen in the excrements compared with that in the food, representing the following percentages of gain on that in the food, 1.0, 0.7, 0.4, 0.4, 0.6, 0.3, 0.1, and 0.1; whilst the deficits represented 1.4 and 0.3 per cent, and one experiment showed neither gain nor loss.

*Gains and losses of nitrogen.*

*Practically no loss of nitrogen.* Since the publication of the various results above quoted, there has been little doubt entertained that, not only in the case of carnivora and omnivora, but also in that of herbivora, and even of ruminants, practically the whole of the nitrogen of the food which does not contribute to animal increase or to milk, reappears in the excrements.

*Manurial residue of foods.* In our estimates of the value of the manure from the consumption of different foods by animals on the farm, so far as the nitrogen was concerned, we many years ago deducted

[1] *Neue Beiträge*, Heft I. p. 383, 1872.
[2] *Journ. f. Landw.*, 1870 and 1871; Armsby, *Manual of Cattle-feeding*, 3rd ed., 1877, pp. 99, 100.
[3] *Zeits. f. Biol.*, 1870, p. 204; Armsby, *loc. cit.*, pp. 100, 101.
[4] Bischoff and Voit, *Die Gesetze der Ernährung des Fleischfressers*, 1860; and Wolff's *Die Ernährung d. landw. Nutzthiere*, 1876.

10 per cent from the amounts consumed in oilcakes and leguminous seeds, which contain high percentages of nitrogen, and 15 per cent from the amounts in the foods which contain lower percentages. These deductions were reckoned to include the amounts of nitrogen actually stored up in the increase of live-weight, and also some little loss if any, but not to cover the larger losses that may take place in the manure after it is voided by the animals. More recently, however, we have estimated the amount actually stored up in the animal, and have assumed the whole of the remainder to be voided in the solid and liquid excretions.

*Valuation of unexhausted manures.*

For details on the point, we must refer to our most recent paper bearing upon the subject, entitled *On the Valuation of Unexhausted Manures.*[1] The calculations relate to the use of food for the production of fattening increase. It is assumed that, on the average, such increase will contain 8 per cent of nitrogenous substance, corresponding to 1.27 per cent of nitrogen in the increase. According to the calculations it results that, of the total nitrogen consumed in foods rich in that substance, such as oilcakes and leguminous seeds, there will generally be less than 5 per cent retained in the fattening increase in live-weight. In the case of the cereal grains, on the other hand, which are much less rich in nitrogen, a much larger proportion of the total amount consumed will be retained in the increase—generally, perhaps, about 10 per cent of it. Of the nitrogen in gramineous straws a still higher proportion will probably be devoted to increase; whilst roots will, on the average, lose by feeding, perhaps, only about 5 or 6 per cent of their nitrogen.

*Percentages of nitrogen assimilated and voided by animals.*

*Fattening animals.*

Thus, when fattening increase only is produced, the proportion of the nitrogen of the food which will be retained by the animal, and so lost to the manure, is very small in the case of the richer foods, but more in that of the poorer ones; though, even with them, it will seldom exceed 10 per cent, except possibly in the case of straws. It may be assumed, however, that when foods are consumed by store animals, whose increase is largely growth, about twice as much of the nitrogen of the food is retained, and so lost to the manure. And when, as is more and more the case with early maturity, the increase comprises a larger proportion of growth than in mere fattening, the amount of the nitrogen of the food which will be lost to the manure will be more than with fattening only, but less than with merely store animals. When, however, food is consumed for the production of milk, a very much greater proportion of its nitrogen will be lost to the manure.

*Growing animals.*

*Cows.*

[1] *Journ. Roy. Ag. Soc. Eng.*, vol. xxi., SS., Part II., 1885.

## FOOD AND THE EXERCISE OF FORCE.

We now come to the last branch of our subject—namely, *The Feeding of Animals for the Exercise of Force.* With the very limited space still left at our disposal, we will commence our historical sketch with a brief account of the views of Liebig as first put forward in 1842 in his work *On Organic Chemistry in its applications to Physiology and Pathology.* There is, indeed, a special appropriateness in so doing, since there can be no doubt that the course of subsequent inquiry and discussion has been materially influenced by the opinions he then enunciated.

*Liebig's views.*

The following quotations from the above-mentioned work will suffice to indicate his more specific views in regard to the connection between food requirements and the exercise of force:—

> As an immediate effect of the manifestation of mechanical force, we see that a part of the muscular substance loses its vital properties, its character of life; that this portion separates from the living part, and loses its capacity of growth and its power of resistance. We find that this change of properties is accompanied by the entrance of a foreign body (oxygen) into the composition of the muscular fibre (just as the acid lost its chemical character by combining with zinc); and all experience proves, that this conversion of living muscular fibre into compounds destitute of vitality is accelerated or retarded according to the amount of force employed to produce motion Nay, it may safely be affirmed that they are mutually proportional; that a rapid transformation of muscular fibre, or, as it may be called, a rapid change of matter, determines a greater amount of mechanical force; and conversely, that a greater amount of mechanical motion (of mechanical force expended in motion) determines a more rapid change of matter. —Pp. 220, 221.

And again:—

> The amount of azotised food necessary to restore the equilibrium between waste and supply is directly proportional to the amount of tissues metamorphosed.
>
> The amount of living matter, which in the body loses the condition of life, is, in equal temperatures, directly proportional to the mechanical effects produced in a given time.
>
> The amount of tissue metamorphosed in a given time may be measured by the quantity of nitrogen in the urine.
>
> The sum of the mechanical effects produced in two individuals, in the same temperature, is proportional to the amount of nitrogen in their urine; whether the mechanical force has been employed in voluntary or involuntary motions, whether it has been consumed by the limbs or by the heart and other viscera.—*Ibid.*, p. 245.

Such, in fact, were the views in regard to the special exigencies of the system in the exercise of force, which became at once identified with Liebig's name, and continued to

be so identified for many years. Thus, Professor Frankland, in his lecture at the Royal Institution in 1866[1] on the experiments of Fick and Wislicenus,[2] refers to these views of Liebig as having, up to that time, been pretty generally adopted by text-book writers.

*Rothamsted researches.*

The results of our own feeding experiments, which were commenced some years after the appearance of Liebig's work, being apparently inconsistent with the then current views on some important points, we were led at once to turn attention to the subject of human dietaries; and also to a consideration of the management of the animal body undergoing somewhat excessive labour, as for instance, the hunting-horse, the racer, the cab-horse, the fox-hound, and also pugilists and runners. The conclusions to which we were led by this study were briefly summarised in a paper published in the *Report of the British Association for the Advancement of Science*, for 1852, as follows:—

*Conclusions of 1852.*

. . . that in the cases, at least of ordinary exercise of force, the exigencies of the respiratory system keep pace more nearly with the demand for nitrogenous constituents of food than is usually supposed; and further:—

A somewhat concentrated supply of nitrogen does, however, in some cases, seem to be required when the system is overtaxed; as for instance, when day by day more labour is demanded of the animal body than it is competent without deterioration to keep up; and perhaps also, in the human body, when under excitement or excessive mental exercise. It must be remembered, however, that it is in butcher's meat, to which is attributed such high flesh-forming capacity, that we have also, in the fat which it contains, a large proportion of respiratory material of the most concentrated kind. It is found, too, that of the dry substance of the *egg*, 40 per cent is pure fat.

*Respiratory material and muscular force.*

A consideration of the habits of those of the labouring classes who are under- rather than over-fed, will show that they first have recourse to fat meat, such as pork, rather than to those which are leaner and more nitrogenous; thus perhaps indicating, that the first instinctive call is for an increase of the respiratory constituents of food. It cannot be doubted, however, that the higher classes do consume a larger proportion of the leaner meats; though it is probable, as we have said, that even with these as well as pork, more *fat*, possessing a higher respiratory capacity than any other constituent of food, is taken into the system than is generally imagined. Fat and butter, indeed, may be said to have about twice and a half the respiratory capacity of starch, sugar, &c. It should be remembered, too, that the classes which consume most of the leaner meats, are also those which consume the most butter, sugar, and in many cases, alcoholic drinks also.

It is further worthy of remark, that wherever labour is expended in the manufacture of staple articles of food, it has generally for its object the concentration of the *non*-nitrogenous, or more peculiarly respiratory constituents. Sugar, butter, and alcoholic drinks are notable instances

[1] *Journ. R. Inst.*, 1866.

[2] *Phil. Mag.*, 1866, 4th series, vol. 31, pp. 485-503.

of this. Cheese, which at first sight might appear an exception, is in reality not so; for those cheeses which bring the highest price are always those which contain the most butter; whilst butter itself is always dearer than cheese.

In conclusion, it must by no means be understood that we would in any way depreciate the value of even a somewhat liberal amount of nitrogen in food. We believe, however, that on the current views too high a relative importance is attached to it; and that it would conduce to further progress in this most important field of inquiry if the prevailing opinions on the subject were somewhat modified.

It is to be borne in mind, that at the time these opinions were put forward, now more than forty years ago, the views expressed were directly contrary to all recognised authority on the subject; and that it is since that date that so much evidence has been accumulated, as to the amounts of urea, and of carbonic acid, given off under varied conditions as to food and exercise. Still, from the facts already at command, it was concluded that the increased demand for food resulting from the exercise of muscular power was specially characterised by the requirement for an enhanced amount of the non-nitrogenous constituents. *Food constituents demanded by labour.*

Confirmatory evidence was, however, not long wanting. Thus, in 1854, we selected two pigs as nearly as possible of equal weight and character; to one was given, *ad libitum*, lentil-meal (containing about 4 per cent of nitrogen), and to the other, also *ad libitum*, barley-meal (containing less than 2 per cent). Each animal was kept in a frame, with arrangements for collecting the fæces and urine separately, as already described. After they had been kept for a certain time on their respective foods, one comparative experiment was conducted for three days, and later on another for ten days. The weights of the animals were taken at the beginning and at the end of each experiment; and, besides other particulars, the amounts of nitrogen consumed in the food, and of urea voided, were determined. The results are summarised in the following table:— *Further trials.*

TABLE 76.—EXPERIMENTS AT ROTHAMSTED WITH PIGS. JUNE TO AUGUST 1854.

*Quantities per head per day.*

| Periods. | Foods. | Nitrogen in food. | Urea voided. | Urea = nitrogen. |
|---|---|---|---|---|
| Days. | | grams. | grams. | grams. |
| 3 | No. 1. Lentil-meal . . | 123.0 | 134.0 | 62.6 |
| 3 | No. 2. Barley-meal . . | 58.9 | 61.5 | 28.7 |
| 10 | No. 1. Lentil-meal . . | 120.6 | 141.0 | 65.8 |
| 10 | No. 2. Barley-meal . . | 51.2 | 52.1 | 24.3 |

The result was, then, that with exactly equal conditions as to exercise, both animals being in fact at rest, the amount of urea passed by the one feeding on the highly nitrogenous lentil-meal was, in each case, more than twice as great as that voided by the one fed on the barley-meal, supplying less than half the amount of nitrogen.

*Liebig's view not confirmed.*

It was clear, therefore, that the rule laid down by Liebig, and so long generally adopted by others, did not hold good, namely, that—"The sum of the mechanical effects produced in two individuals in the same temperature is proportional to the amount of nitrogen in their urine; whether the mechanical force has been employed in voluntary or involuntary motions, whether it has been consumed by the limbs or by the heart and other viscera"—unless, indeed, as has been assumed by some experimenters, that there is, with an increase of nitrogenous substance in the food, an increased amount of mechanical force employed in the "involuntary motions" sufficient to account for the increased amount of urea voided.

It was at any rate obvious that, if the amount of urea voided by one animal at rest could be more than twice as great as that voided by a similar animal also at rest, and under otherwise equal conditions, provided only that the food of the one contained more than twice as much nitrogen as that of the other, the amount of urea passed could not be any measure of the amount of muscular power exerted.

The subject was taken up again at Rothamsted in 1862, and accordant results were obtained as follows:—

*Later trials.*

TABLE 77.—EXPERIMENTS AT ROTHAMSTED WITH PIGS. AUGUST–SEPTEMBER 1862.

*Quantities per head per day.*

| Periods. | Foods. | Nitrogen in food. | Urea voided | Urea = nitrogen. |
|---|---|---|---|---|
| Days. | | grams. | grams. | grams. |
| 10 | No. 1. Barley and bran . | 41.6 | 43.6 | 20.4 |
| 10 | No. 2. Beans and bran . | 66.0 | 89.6 | 41.8 |
| 5 | No. 1. Barley and bran . | 46.2 | 52.3 | 24.4 |
| 5 | No. 2. Beans and bran . | 82.5 | 116.6 | 54.4 |

*Dr E. Smith's trials.*

Not long after the publication of our views in 1852, and the experiments with pigs in 1854, with the results of which he was acquainted, the late Dr Edward Smith instituted experiments to determine the amounts of carbonic acid exhaled in respiration under various conditions as to muscular exercise. His results were published in a paper presented to the

Royal Society on December 16, 1858.[1] He records the quantities of carbonic acid exhaled in grains per minute, and these we have calculated into grams per hour, and so give them below :—

*Muscular exercise and exhalation of carbonic acid.*

| | Carbonic acid, grams per hour. |
|---|---|
| During light sleep | 19.2 |
| Lying down, scarcely awake | 23.0 |
| Sitting quietly | 38.1 |
| Walking two miles per hour | 70.4 |
| Walking three miles per hour | 100.4 |
| On treadwheel, ascending 28.65 feet per minute | 189.2 |

There was, therefore, very greatly increased exhalation of carbonic acid with increased muscular exercise.

*Labour and voiding of urea.*

Dr E. Smith also conducted experiments on the amounts of urea eliminated under different conditions, both as to food and exercise. The investigation was commenced in January 1860, and continued up to March 1862, a period of two years and two months. These results were also published in a paper in the *Philosophical Transactions* of the Royal Society.[2] The general result was, that there was great variation in the amount of urea passed when there was concurrent variation in the amount of nitrogenous substance in the food; but, on the other hand, comparatively little variation in the amount of urea voided, with great variation in the amount of labour performed.

*Confirming Rothamsted views.*

Thus, then, Dr Smith's results, both those showing the amounts of carbonic acid exhaled, and those relating to the amounts of urea voided, fully confirmed the view that with muscular exertion there was marked increase in the demand for the non-nitrogenous, and but little if any in that for the nitrogenous, constituents of food.

*Voit's experiments.*

Experiments made by Bischoff and Voit in 1858 and 1859[3] with a dog, either submitted to hunger, or fed from time to time on foods containing very different amounts of nitrogenous substance, showed very variable amounts of urea voided, although the animal was kept under equal conditions as to exercise. Still, on the publication of their results in 1860, the authors assumed, that although there had been no greater exercise of force manifested in the form of external work, yet when the amount of nitrogenous substance in the food was greater, and the amount of urea voided correspondingly greater, there must have been a corresponding increase in the force exercised in the conduct of the actions within the

*Voit's views.*

[1] *Phil. Trans.*, 1859, vol. 149, pp. 681-742.
[2] *Phil. Trans.*, 1861, vol. 151, pp. 747-834.
[3] *Die Gesetze der Ernährung des Fleischfressers*, 1860.

body, in connection with the disposition of the increased amount of nitrogenous substance consumed; so that, after all, the amount of urea eliminated was a measure of the exercise of force, though not in the voluntary exercise of muscular power.

*Interview with Voit.* One of us being in Germany in the summer of 1860, and visiting Munich, had some conversation with Professor Voit on the subject of their results and conclusions. Referring to our own results obtained in 1854 with pigs, it was pointed out that they were entirely consistent with those which he and Professor Bischoff had obtained with a dog, but that we had drawn very different conclusions from them. He conveyed the impression, however, that he considered we were entirely in error.

*Further trials by Voit.* Later in the same year, however, Voit published[1] the results of further experiments with a dog. In these, he submitted the animal to alternate rest and labour, sometimes fasting, sometimes with a moderate, and sometimes with a liberal supply of nitrogenous substance in food. The labour consisted of working in a kind of treadwheel. He found that the amount of urea eliminated was not in proportion to the exercise of force, but was very nearly proportional to the amount of nitrogenous substance consumed. He considered that by such a result the views which he and others had maintained as to the connection between the exercise of force, the degradation of nitrogenous substance within the body, and the elimination of urea, were completely overturned.

*Former views overturned.*

In 1862 Pettenkofer and Voit published a paper[2] giving the results of experiments with a dog made in 1861 and 1862, in which the food consumed, the amount of urea voided, and the quantity of carbonic acid given off by the lungs and skin, were determined—the latter in Pettenkofer's respiration apparatus. These experiments were more or less preliminary, and during their conduct the animal was not submitted to any labour.

*Experiments by Pettenkofer and Voit.* Subsequently, Pettenkofer and Voit made experiments in which they determined both the nitrogen in the urine, and the carbonic acid evolved, not only in rest but in work; sometimes fasting, and sometimes with food. Their results were published in 1866 in the *Zeitschrift fur Biologie.* Table 78 gives average results for twenty-four hours, in experiments made with a man, with the aid of Pettenkofer's respiration apparatus.

Thus, not only was there no increased transformation of

[1] *Untersuchungen uber den Einfluss des Kochsalzes, Kaffees und der Muskelbewegungen auf den Stoffwechsel,* 1860.

[2] *Ann. Chem. Pharm.*, II. Supplement-band, I. Heft, p. 52.

nitrogenous substance by the exercise of force, but there was a very greatly increased exhalation of carbonic acid. It is evident, therefore, that in the exercise of force, the exigency of the system is specially characterised by an increased demand in the food for, so to speak, respiratory material. The results of Pettenkofer and Voit are indeed of great importance; but in Germany they are even looked upon as being the first to establish the correct view on the subject.

*Confirming Rothamsted results.*

TABLE 78.

| | Nitrogen in urine. | Carbonic acid exhaled. |
|---|---|---|
| IN HUNGER. | | |
| | grams. | grams. |
| In rest . . . . . . . | 12.39 | 716 |
| In work . . . . . . . | 12.26 | 1187 |
| WITH MODERATE DIET. | | |
| In rest . . . . . . . | 17.01 | 928 |
| In work . . . . . . . | 17.33 | 1209 |

Abundant further confirmation of the now generally accepted view is available, and it will be of interest to give some illustrations.

In 1866 results were published[1] as to the amount of nitrogen excreted before, during, and after ascending the Faulhorn, by Professor Fick and Wislicenus, in August 1865. The experimenters took an ordinary meal at mid-day on the 29th, but then only starch, fat, and sugar until after the ascent, which commenced early the next morning. Table 79 is a summary of the results so far as they relate to the point under consideration.

*Results in human labour.*

The record of the actual quantities is sufficient to show that much less nitrogen was excreted by both experimenters during, and after, than before the ascent. But the calculated amounts of nitrogen excreted per hour during each of the periods, as given in the last column of the table, bring the main results more clearly to view. It is seen that, on the average, only about two-thirds as much nitrogen was excreted per hour during and after the ascent, as prior to it, when there would be more or less residue in the system from the last albuminous meal.

The above results of Fick and Wislicenus were brought forward by Professor Frankland, in a lecture which he gave at the Royal Institution in 1866—*On the Source of Muscular*

*Frankland on the source of muscular power.*

[1] *Phil. Mag.*, 1866, 4th Series, vol. 31, pp. 485-503.

*Power.* He subsequently himself made numerous calorimetrical determinations of the energy evolved by the combustion of muscle, urea, and various foods, or constituents of foods, the results of which were published in a paper—*On the Origin of Muscular Power.*[1] Stated in a few words, his main conclusion was, that the transformation of muscular tissue alone cannot account for more than a small fraction of the muscular power developed by animals.

TABLE 79.

| | Urea | Nitrogen in urea. | Total nitrogen. | Nitrogen excreted per hour (average) |
|---|---|---|---|---|
| FICK. | | | | |
| | grams | grams | grams. | grams. |
| Night before ascent . . | 12.4820 | 5.8249 | 6.9153 | 0.63 |
| During ascent . . . | 7.0330 | 3.2681 | 3.3130 | 0.41 |
| After ascent. . . . | 5.1718 | 2.4151 | 2.4293 | 0.40 |
| Night after ascent . . | ... | ... | 4.8167 | 0.45 |
| WISLICENUS. | | | | |
| | grams. | grams | grams. | grams. |
| Night before ascent . . | 11.7614 | 5.4887 | 6.6841 | 0.61 |
| During ascent . . . | 6.6973 | 3.1254 | 3.1336 | 0.39 |
| After ascent. . . . | 5.1020 | 2.3809 | 2.4165 | 0.40 |
| Night after ascent . . | ... | ... | 5.3462 | 0.51 |

*Kellner's experiments.*

Dr Oskar Kellner, who was one of Professor Emil von Wolff's associates in numerous investigations with animals at Hohenheim, made experiments there with a horse[2] from June 15 to August 10, 1878. The daily food of the animal consisted of 5 kilog. meadow-hay, 6 kilog. oats, and 1.5 kilog. wheat-straw-chaff. The horse was made to go different distances, and to draw different weights, the draught being measured by a horse-dynamometer.

Table 80 gives a summary of some of the conditions and results of the experiments.

*Increased excretion of nitrogen with increased work.*

In reference to these results, which certainly do show an increased excretion of nitrogen with increased work during the second, third, and fourth periods, as compared with the first and fifth, Kellner considers that they are inconsistent with the conclusions of Pettenkofer and Voit, and others, which connect muscular action more exclusively with the oxidation of non-nitrogenous matters, and that those views require to be modified. At the same time, admitting that the transfor-

[1] *Phil. Mag.*, 1866, 4th Series, vol. 32, pp. 182-199.
[2] *Landwirthschaftliche Jahrbucher*, vol. viii., part v., 1879, pp. 701-712.

mation of organic substance is to be considered the source of muscular power, he considers that, in the first line, comes the oxidation of non-nitrogenous matters, carbohydrates and fat; in the second, the transformation of circulation-albumen; and lastly, that of the organised albumin, which is only attacked if other matters are not available in sufficient quantity. Further, he considers it is evident that the increased albumin transformation was not sufficient to cover the requirements of the increased work, and that this increased transformation, and the loss of body-weight, show the insufficiency of the food, and of the available fat of the body.

TABLE 80.

| Experiments. | Number of days. | Live-weight | Per day. | | |
|---|---|---|---|---|---|
| | | | Work done, kilogram-metres. | Urine voided. | Nitrogen in urine. |
| | | kilog | kg.-m. | c.c. | grams. |
| 1 | 6 | 534.1 | 475,000 | 6730 | 99.0 |
| 2 | 10 | 529.5 | 950,000 | 6473 | 109.3 |
| 3 | 14 | 522.5 | 1,425,000 | 8106 | 116.8 |
| 4 | 12 | 508.8 | 950,000 | 8686 | 110.2 |
| 5 | 14 | 518.0 | 475,000 | 9548 | 98.3 |

*Probable explanation of Kellner's results.*

The table, in fact, does show that, with increased work done, there was decline in body-weight; and, assuming with Kellner that there was a deficiency of food and of body fat, it seems probable that the increased elimination of nitrogen in the urine is the necessary coincident of real dilapidation of the system. It is obvious that, so far as this is the case, the results are not discordant with our own early view on the subject, since fully established by others. These results of Kellner's are, indeed, a confirmation of the view we put forward in 1852, that "a somewhat concentrated supply of nitrogen does, however, in some cases, seem to be required when the system is overtaxed; as for instance when, day by day, more labour is demanded of the animal body than it is competent without deterioration to keep up."

*Grandeau and Leclerc's experiments.*

In 1885 Grandeau and Leclerc published the results of an experiment with a horse[1] of which the following is a summary:—

| | | Nitrogen in urine for 100 in food. |
|---|---|---|
| Rest | | 62.4 per cent. |
| Walking | | 67.7 " |
| Trotting | | 64.9 " |
| Drawing | Walking | 60.9 " |
| | Trotting | 59.2 " |

[1] *Annales de la Science Agronomique*, 1885, 2me *année*, tome i. p. 326.

The results show, over the first three experiments, some, but not great, variation in the amount of nitrogen eliminated with exercise; but the amounts are less in the fourth and fifth experiments, and almost identical with walking and trotting. Upon the whole, there is no evidence of direct connection between the amount of exercise of force and that of nitrogen eliminated in the urine.

*Zuntz and Lehmann's experiments.*

The next results give very definite evidence as to the connection between the amount of carbonic acid exhaled, and that of the force exercised. The experiments were made with a horse, by Zuntz and Lehmann, in 1887 and 1888,[1] and the average results were as follows:—

| | Carbonic acid exhaled per hour (average). With Mask. | With Tracheal-canula. |
|---|---|---|
| Rest . . . . . | 3.327 cubic feet. | 2.861 cubic feet. |
| Work . . | 19.643 " | 17.291 " |
| After work . . | 4.662 " | 3.899 " |

*Exhalation of carbonic acid at work and rest.*

Thus, then, there were about six times as much carbonic acid exhaled per hour during work as in rest; and when the work had ceased, there was very great reduction in the amount of carbonic acid given off.

*F. Smith's results.*

The following results by Professor F. Smith, of Aldershot, were published by him in the *Journal of Physiology*[2] in 1890:—

TABLE 81.

| | $CO_2$ expired per hour | | |
|---|---|---|---|
| | Pony (work, trotting). | Horse (work, galloping). | Horse (work, galloping). |
| | cubic feet. | cubic feet | cubic feet |
| Rest . . . . . . | 0.7648 | ... | ... |
| Work . . . | 2.3954 | 20.6265 | 12.4353 |
| After work . . . . | 0.4631 | 1.3133 | 1.1693 |

As in the experiments of Zuntz and Lehmann, quoted above, the great increase in the amount of carbonic acid exhaled during work, and the great reduction in the amount after the cessation of the work, are here again clearly illustrated.

Table 82 summarises numerous results, by Professor F Smith, with horses at different paces (*loc. cit.*, p. 77).

These strictly gradationary results, with one slight exception, illustrate more clearly still the greater exhalation of carbonic acid the greater the exercise of force.

[1] *Landw. Jahrbucher*, vol. xviii, 1889, p. 1. [2] Vol. xi., No. 1.

TABLE 82.

| | $CO_2$ expired per hour. | |
|---|---|---|
| | Series A. | Series B. |
| | cubic feet. | cubic feet. |
| Rest . . . . . . . | 1.0282 | 1.2346 |
| Walking . . . . . . | 1.0972 | 1.0586 |
| Trotting . . . . . . | 2.9482 | 4.8309 |
| Cantering . . . . . . | 4.9159 | 5.0080 |
| Galloping . . . . . . | 14.9725 | ... |

Turning from the foregoing evidence of direct experiment, indicating the characteristic food requirements for the exercise of force, it will be of interest to give a few examples of the rations adopted as the joint result of direct experiment and large experience.

*Adopted rations.*

At p. 345 the results of some experiments by Grandeau and Leclerc with a horse were given, showing no direct connection between the amount of force exercised and that of nitrogen eliminated in the urine. Their experiments were made at the establishment of the *Petites Voitures* Company in Paris; and the following table gives the standard daily ration of the horses at the time, the experimentally determined maintenance ration, and that finally adopted for work:—

*Rations for horses in Paris.*

TABLE 83.

| Ration. | Beans. | Oats. | Maize. | Maize-cake. | Hay. | Straw. | Total food. | Total dry substance. |
|---|---|---|---|---|---|---|---|---|
| | lb. | lb. | lb. | lb. | lb. | lb | lb | lb. |
| Previous . . . | 1.54 | 7.23 | 5.34 | 1.06 | 3.84 | 2.09 | 21.10 | 18.14 |
| Maintenance, No. 1 . | 0.93 | 4.34 | 3.20 | 0.63 | 2.30 | 1.24 | 12.64 | 10.87 |
| Maintenance, No. 2 . | 0.84 | 3.91 | 2.88 | 0.57 | 2.07 | 1.12 | 11.39 | 9.79 |
| For work . . . | 1.39 | 6.51 | 4.81 | 0.95 | 3.46 | 1.87 | 18.99 | 16.33 |

It seems that the system of the establishment was to work the horses alternate days; and to give less hay, straw, and maize, but more oats and beans, though less total food, on the days of work. The figures in the top line, representing the "Previous" ration, are, in each case, the means of the two days' ration. The "Maintenance Ration, No. 1," was fixed at three-fifths of the "Previous" ration; but, as the animals gained in weight, the "Maintenance Ration, No. 2," which

was one-tenth less than No. 1, was subsequently adopted. Even then the horses rather gained in weight. Finally, as it was considered that the standard or "Previous" ration was too high, the ration for work, as given in the bottom line of the table, which is one-and-a-half time as much as the "Maintenance Ration, No. 1," and about one-tenth less than the "Previous" ration, was adopted. It is, however, said that under the new *régime* the horses were somewhat under-fed, but whether the reduced ration is still maintained we are not aware. It will be observed that the proportion of the highly nitrogenous leguminous corn (beans) was very small compared with that of the gramineous grains. Still, it will be seen presently that the proportion was very considerably higher than in the case of the omnibus horses of Paris.

The following table gives the average daily ration of the horses of the *General Omnibus Company* of Paris for each of the six years—1879, 1880, 1884, 1885, 1886, and 1887. The average number of horses was about 13,000, and their average weight was from 1200 to 1240 lb., whilst, so far as the evidence goes, those of the *Petites Voitures* Company weighed little more than two-thirds as much; and certainly the former are much heavier than as a rule are the omnibus or tramway horses of our own country. The figures are calculated from the results given in the annual reports of M. E. Lavalard,[1] the general secretary of the company, the quantities being converted from kilograms into their equivalent in English pounds:—

TABLE 84.

| | Beans. | Oats | Maize | Hay. | Straw. | Bran, &c. | Total food | Total dry substance. |
|---|---|---|---|---|---|---|---|---|
| | lb. | lb. | lb. | lb | lb | lb. | lb. | lb. |
| 1879 | 1.36 | 10.04 | 6.85 | 9.14 | 10.45 | ... | 37.84 | 32 17 |
| 1880 | 1.41 | 8.84 | 8.25 | 7.80 | 11.10 | ... | 37.40 | 31.83 |
| 1884 | 1.44 | 8.67 | 8.53 | 8.44 | 8.71 | 0.91 | 36.70 | 31.29 |
| 1885 | 0.89 | 6.21 | 11.30 | 8.50 | 8.36 | 0.84 | 36.10 | 30.84 |
| 1886 | 0.10 | 5.51 | 12.96 | 8.64 | 7.32 | 0.54 | 35 07 | 30.03 |
| 1887 | 0.01 | 8.08 | 10.77 | 8.65 | 8.21 | ... | 35.72 | 30.52 |

It will be seen that the actual amount of dry substance supplied per head per day is nearly twice as much as in the case of the *Petites Voitures* horses; that is, much more in proportion to a given live-weight. It will be further seen that the proportion of beans to cereal grains is much less than in the case of the *Petites Voitures* horses, and was reduced to a very small quantity in the later years. In fact, the corn

[1] *Rapports sur les opérations du service de la Cavalerie et des Fourrages.*

given consisted almost exclusively of oats and maize, that of the oats being reduced, but that of the maize in a greater degree increased, in the later years, coincidently with the reduction in the amount of beans. On the occasion of a visit of one of us to M. Lavalard in 1887, it was suggested to him that the supply of the highly nitrogenous leguminous seeds might be mainly, if not exclusively, reserved for old or overworked horses; and he subsequently informed us that he had found their use in such cases advantageous.

*Rations for British tramway horses.*

In his annual report for 1886, published in 1887, M. Lavalard gives, on the authority of Dr Fleming, Principal Veterinary Surgeon of the army, a list of the average daily rations of horses of tramway companies in the United Kingdom, which are quoted in the following table from Dr Fleming's book.[1] We have also calculated the quantity of dry substance in the total food according to the supposed average composition of each.

There can be little doubt that the average weight of tramway horses in the United Kingdom is much less than that of the omnibus horses of Paris, and it will be seen that the quantity of total food, or total dry matter of food, given per head per day is also considerably less; though it is much greater than in the case of the smaller *Petites Voitures* horses of Paris.

TABLE 85.

| | Beans or peas. | Oats. | Maize. | Hay. | Straw. | Bran. | Total food. | Total dry substance. |
|---|---|---|---|---|---|---|---|---|
| | lb. | lb. | lb. | lb | lb. | lb. | lb. | lb. |
| North Metropolitan | 2 | 3 | 13 | 7 | 3 | ... | 28 | 24.09 |
| London . . . | 3 | 3 | 7 | 12 | 1 | ... | 26 | 22.20 |
| London Street . | 1 | 3 | 12 | 11 | ... | 1 | 28 | 24.09 |
| South London . | 1 | 7 | 7 | 11 | 3 | ... | 29 | 24.76 |
| Birmingham . . | 4 | 10 | 6 | 12 | | ... | 32 | 27.30 |
| Liverpool . . | 4 | ... | 12 | 14 | ... | 1 | 31 | 26.58 |
| Manchester . . | | 15 | | 15 | ... | ... | 30 | 25.55 |
| Glasgow . . . | ... | 6 | 11 | 8½ | 1 | 0½ | 27 | 23.24 |
| Edinburgh . . | 4 | 8 | 4 | 14 | ...[1] | ... | 32 | (25.56) |
| Dublin . . . | ... | 3 | 14 | 12 | ... | 0½ | 29½ | 25.41 |

[1] Also 2 lb. of "Marshlam"—(Mashlun—mixed corn ?).

The details show that, at any rate at that date, the tramway horses in the United Kingdom received much more of the highly nitrogenous leguminous corn, beans or peas, than the Paris horses; and, according to the figures, this was

[1] *The Practical Horse-Keeper*, by C. Fleming, LL.D., p. 88.

especially the case in Birmingham, Liverpool, and Edinburgh. Oats and maize, nevertheless, contributed most of the corn; the maize generally predominating, whilst at the present time it will doubtless do so in a greater degree.

*Review of results.* Reviewing the whole of the results which have been adduced illustrating the characteristic food requirements for the exercise of force, it may in the first place be observed that the evidence is cumulative and decisive that, with normal feeding, and with only moderate exercise, there is practically no increased demand for the nitrogenous constituents of food; whilst there is, on the other hand, an increased demand for the more specially respiratory constituents, largely in proportion to the amount of force exercised. If, however, the labour is abnormally heavy—that is, if it be pushed to the point of dilapidation, as indicated by loss of weight—there will, in that case, be an increased elimination of nitrogen in the urine, resulting from the degradation of nitrogenous substance, and accordingly an increased demand for the nitrogenous constituents of food.

*Constituents of labour rations.* Lastly, it is of interest to observe, that where the subject has been the most carefully investigated, the rations adopted for horses include scarcely any of the more highly nitrogenous foods, such as leguminous seeds; but, in addition to hay and straw-chaff, consist almost exclusively of the comparatively low-in-nitrogen cereal grains, and would, therefore, be characterised by containing a comparatively large amount of digestible non-nitrogenous constituents in proportion to the digestible nitrogenous substance of the food. It has, however, been found that in the case of old or overworked animals, it is advantageous to supply a somewhat larger amount of the highly nitrogenous leguminous seeds. In fact, as we put it in 1852—"a somewhat concentrated supply of nitrogen does, however, in some cases, seem to be required when the system is overtaxed; as for instance, when day by day more labour is demanded of the animal body than it is competent without deterioration to keep up."

## SUMMARY ON THE FEEDING OF ANIMALS.

In introducing the subject of the feeding of the animals of the farm, attention was first called to the amount of the constituents of the crops grown in an ordinary four-course rotation, which would, if the grain only were at once sold, be retained upon the farm for further use—in fact, for the production of meat, milk, and manure, and for the exercise of force. There will, as a rule, be a greater or less amount of grass in admixture with the arable land of the farm; and,

according to its amount and other circumstances, there will, of course, be more or less stock-food available in addition to that produced on the arable land. So far as manure is concerned, in some cases the grass-land, and in others the arable, will be the gainer by the admixture of the two, accordingly as the one or the other receives back more or less than the amount derived from the consumption of its own produce. Then, again, the influence of the growing modern practice of selling more than the grain, and of importing cattle food and manure from external sources, has to be taken into account. Nevertheless, the illustration derived from a consideration of the proportion of the constituents of the crops grown under a particular system of rotation, which will probably be available for feeding purposes, is not without interest and utility.

*Relative importance of nitrogenous and non-nitrogenous constituents.*

The facts and arguments which have been adduced may be very briefly summarised as follows. It has been shown that the amount of food consumed, both for a given live-weight of animal within a given time, and for the production of a given amount of increase, is, as our current food-stuffs go, measurable more by the amounts they contain of digestible and available non-nitrogenous constituents, than by the amounts of the digestible and available nitrogenous constituents they supply.

That this should be the case, so far as the consumption for a given live-weight within a given time is concerned, seems consistent enough when the prominence of the respiratory function in the maintenance of the body, and the large requirement for non-nitrogenous constituents of food to meet the expenditure by respiration, are borne in mind. But, at first sight, it seems less intelligible that the quantities consumed to produce a given amount of increase in live-weight, should also be much more dependent on the supplies of the non-nitrogenous, than on those of the nitrogenous constituents of food.

*Proportion of fat and nitrogenous matter in increase in live-weight.*

It has been shown, however, that store animals may contain as much, or even more, of the non-nitrogenous substance—fat—than of nitrogenous substance; whilst the bodies of fattened animals may contain two, three, four, or more times as much dry fat as dry nitrogenous matter. Obviously, therefore, the proportion of fat to nitrogenous substance in the increase in live-weight of the fattening animal, must be much higher than in the entire bodies of the animals.

*Source of fat.*

Then, it has been further shown that the non-nitrogenous substance of the increase—the fat—is at any rate in great part, if not entirely, derived from the non-nitrogenous constituents of the food.

*Proportions of nitrogen retained and voided.*

Of the *nitrogenous* compounds of food, on the other hand, only a small proportion of the whole consumed is finally stored up in the increase of the animal. In other words, a very large amount of nitrogen passes through the body beyond that which is finally retained in the increase, and so remains for manure.

It is, therefore, only what should be expected, that the amount of food consumed to produce a given amount of increase in live-weight, as well as that required for the sustenance of a given live-weight for a given time, should, provided the food be not abnormally deficient in nitrogenous substance, be characteristically dependent on its supplies of digestible and available non-nitrogenous constituents.

*Force and food.*

Again, it has been shown that, in the exercise of force, there is a greatly increased expenditure of the non-nitrogenous constituents of food, but little, if any, of the nitrogenous.

*Food for maintenance, increase, and force.*

Thus, then, for maintenance, for increase, and for the exercise of force, the exigencies of the system are characterised more by the demand for the digestible non-nitrogenous or more specially respiratory and fat-forming constituents, than by that for the nitrogenous or more specially flesh-forming ones.

*Composition of oxen, sheep, and pigs.*

In our paper—*On the Composition of Oxen, Sheep, and Pigs, and of their Increase whilst Fattening*—published in 1860,[1] we concluded that—if fattening oxen were liberally fed upon good food, composed of a moderate proportion of cake or corn, some hay or straw chaff, with roots or other succulent food; if sheep were fattened under somewhat similar conditions, but with a less proportion of hay or straw; and if pigs were liberally fed chiefly on cereal grain—the increase would, with as much as 5 or 6 parts of total non-nitrogenous to 1 of nitrogenous compounds in the dry substance of such fattening food, probably be very fat. Further, that in the earlier stages of growth and feeding, a lower proportion of total non-nitrogenous constituents, that is, a higher proportion of the nitrogenous compounds, is desirable; indeed, that it is frequently the most profitable, having regard both to the rapidity of fattening and to the value of the manure, for the farmer to employ, even up to the end of the feeding process, a somewhat higher proportion of nitrogenous constituents in his stock-foods, than is necessary to yield the maximum proportion of increase in live-weight for a given amount of dry substance of food consumed. But that, when the mixed fattening food contains less than about 5 parts of non-nitrogenous to 1 of nitrogenous compounds, the propor-

[1] *Jour. Roy. Ag. Soc. Eng.*, 1st Series, vol. xxi., 1860, p. 433.

tion of increase in live-weight for a given amount of dry substance of the food will not increase with the increased proportion of nitrogenous compounds consumed; whilst, so far as these are in excess, the proportion of carcass in the live-weight will probably be somewhat less, and the carcasses themselves will be somewhat more bony and fleshy, and less fat.

*Estimating value of foods.*

We at the same time pointed out, however, that the comparative values of food-stuffs, *even as such*, could not be unconditionally determined by the percentage of the total nitrogenous and the total non-nitrogenous constituents; that it was necessary—to examine more closely into the nature and condition of the proximate compounds of food-stuffs; to distinguish those which are digestible and assimilable from those which are not so; to determine the relative values of the comparable or mutually replacable portions; and, finally, to fix our standards of comparative value with more of reference to direct experimental evidence on the point, and to existing knowledge of the composition of the animal bodies, than had hitherto been usual or even possible.

*Necessity for care in applying estimates of food values.*

Since then, an immense amount of labour has been expended in the determination of the digestibility of the individual constituents of various food-stuffs; and the results so far obtained form a valuable contribution to our information on the subject. There is, however, wide variation in the composition of different samples of nominally the same description of food. Then, the determinations of the amounts of the various constituents remaining undigested have generally been made with animals fed on limited supplies of food, for maintenance only; and the experiments have frequently been made with the individual foods given separately. Great care and reservation are, therefore, necessary in the application of the results to actual practice. Thus, in the liberal feeding of animals for the production of increase, it is generally economical to give, within limits, an excess of food, if a maximum result is to be obtained for a given live-weight of animal within a given time; and, in the case of animals liberally fed for the exercise of force, there will also generally be an excess of food given. It is obvious that, under the conditions of actual practice here assumed, greater proportions of the various constituents consumed will remain undigested than would be indicated by the figures representing indigestibility obtained under the usual conditions of experimenting on the point above referred to. Then there is the important consideration, that conclusive evidence is still wanting as to the exact *rôle* in the system of some prominent constituents of food-stuffs. For example, there is yet much uncertainty

*Uncertainty as to function of food constituents.*

in regard to the position of the various amides, which enter so largely into the composition of feeding roots and hays—in fact of all succulent and unripened products. Indeed, in the calculation of "nutritive ratios," the amides have sometimes been classed with the albuminoids, and sometimes in large proportion with the non-nitrogenous constituents. We have, from time to time, had the results of our numerous feeding experiments, with both sheep and pigs, calculated according to the published tables of digestibility. But the so-calculated "ratios" varied so considerably for different rations within the range of good practice, that it would be misleading to attempt to give anything like a summary of the results, and general conclusions therefrom, without full discussion.

*Relative value of nitrogenous and non-nitrogenous constituents.*

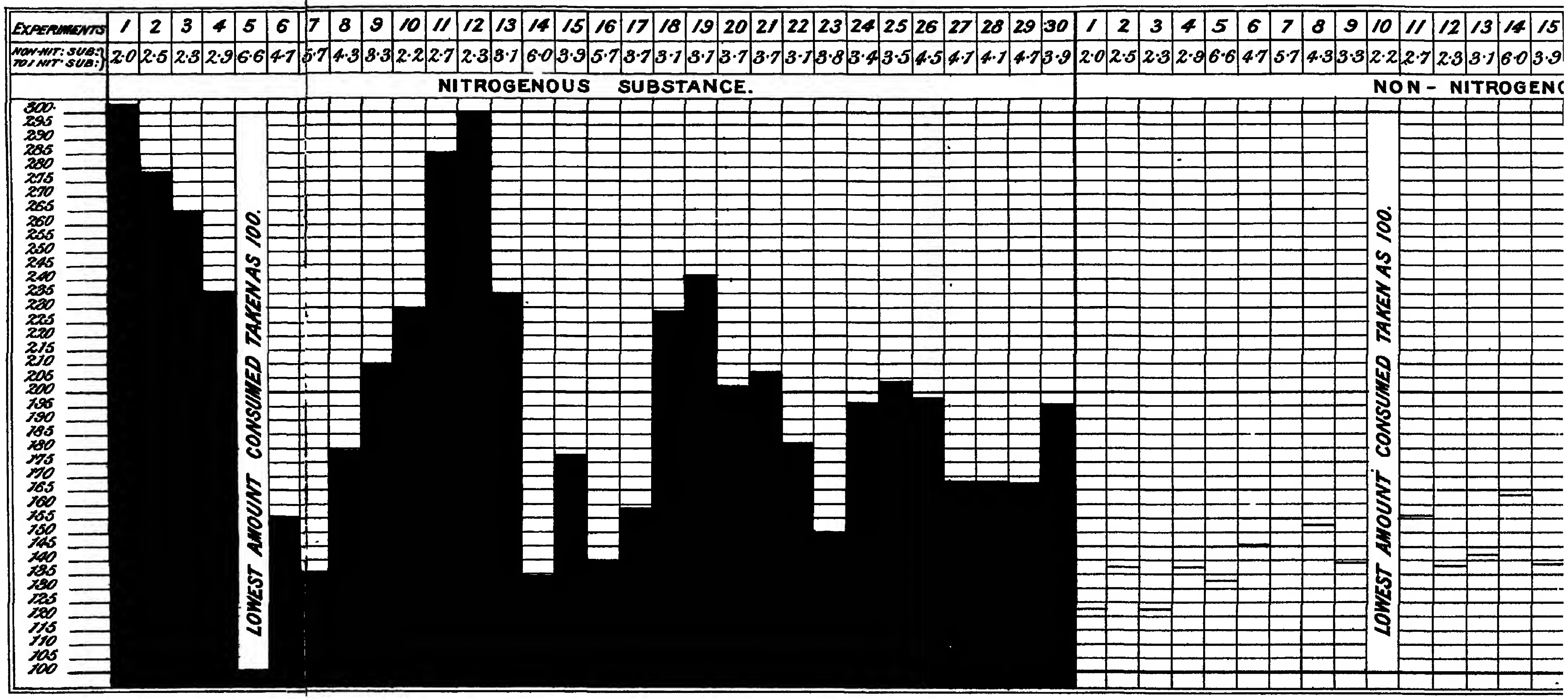
In conclusion, as our current fattening food-stuffs go, assuming, of course, that they are not abnormally low in the nitrogenous constituents, they are, *as foods*, more valuable in proportion to their richness in digestible and available non-nitrogenous than to that of their nitrogenous constituents. As, however, the manure of the animals of the farm is valuable largely in proportion to the nitrogen it contains, there is, so far, an advantage in giving a food somewhat rich in nitrogen, provided it is in other respects a good one, and, weight for weight, not much more costly.

# EXPERIMENTS AT ROTHAMSTED

RESULTS OF EXPERIMENTS WITH 30 LOTS OF PIGS, CONDUCTED 1850–54; FOODS CONT

*One Food always ad libitum; hence th*

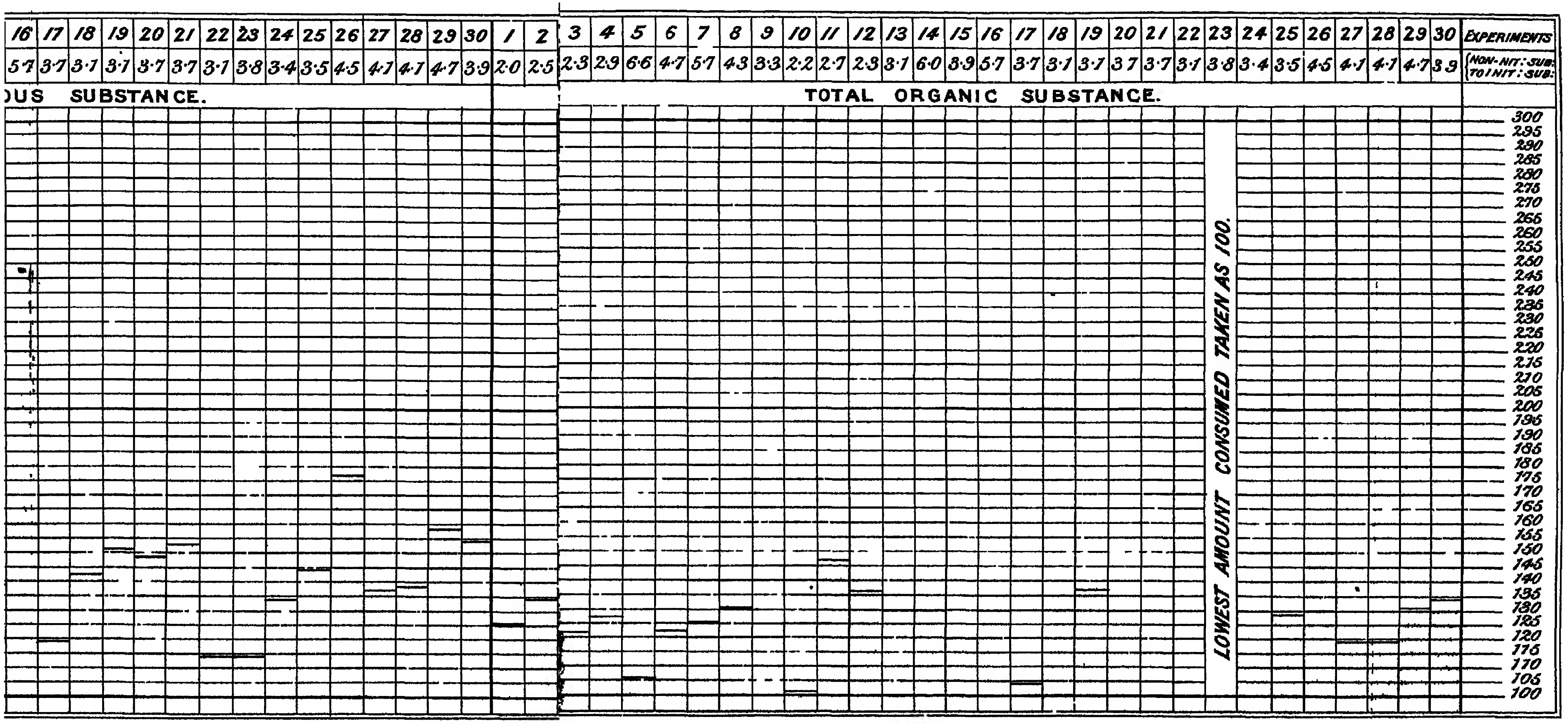
## DIAGRAM I.—SHOWING THE PROPORTIONS OF NITROGENOUS, OF NON-NITROGENOUS, AI



AINING VARIOUS PROPORTIONS OF NITROGENOUS AND NON-NITROGENOUS CONSTITUENTS.

*, Animals fixed their own Consumption.*

ND OF TOTAL ORGANIC SUBSTANCE, CONSUMED PER 100 LB. LIVE-WEIGHT PER WEEK.



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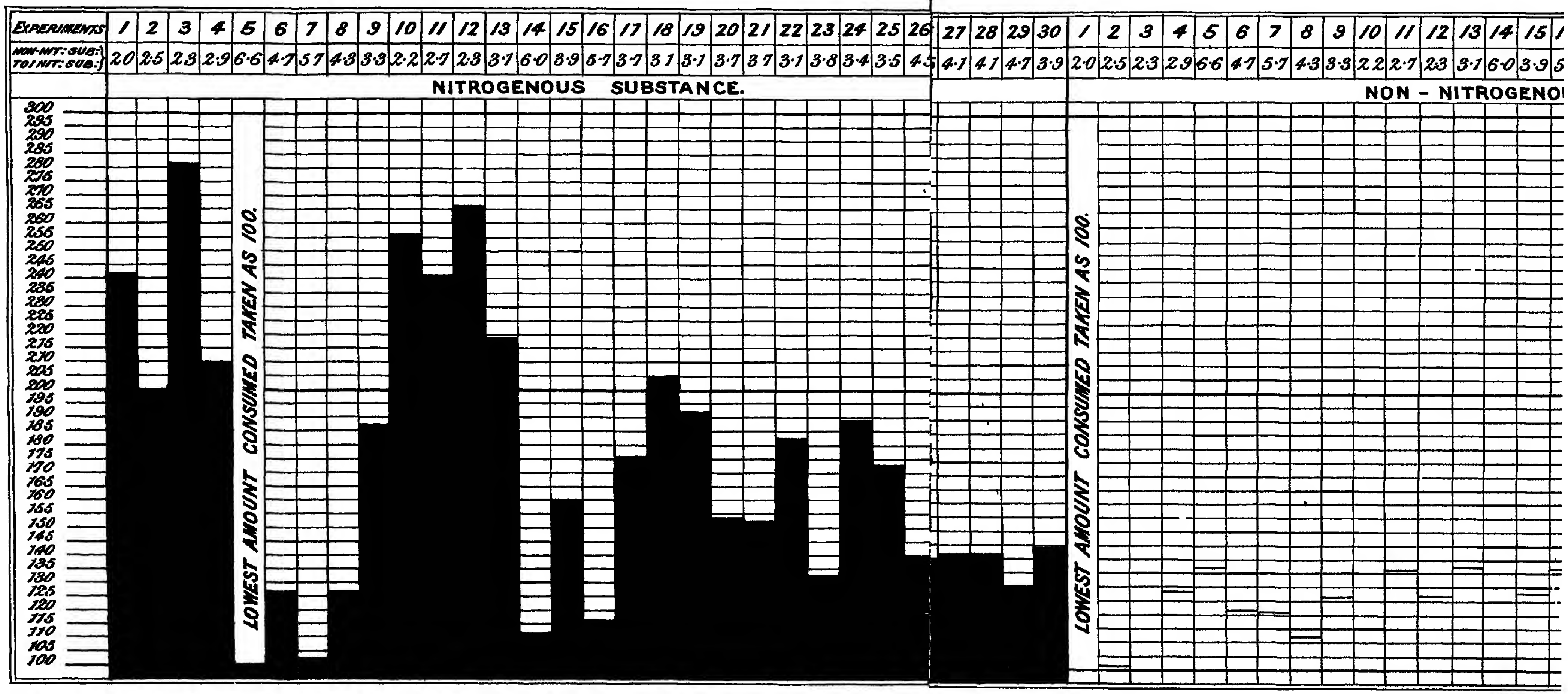

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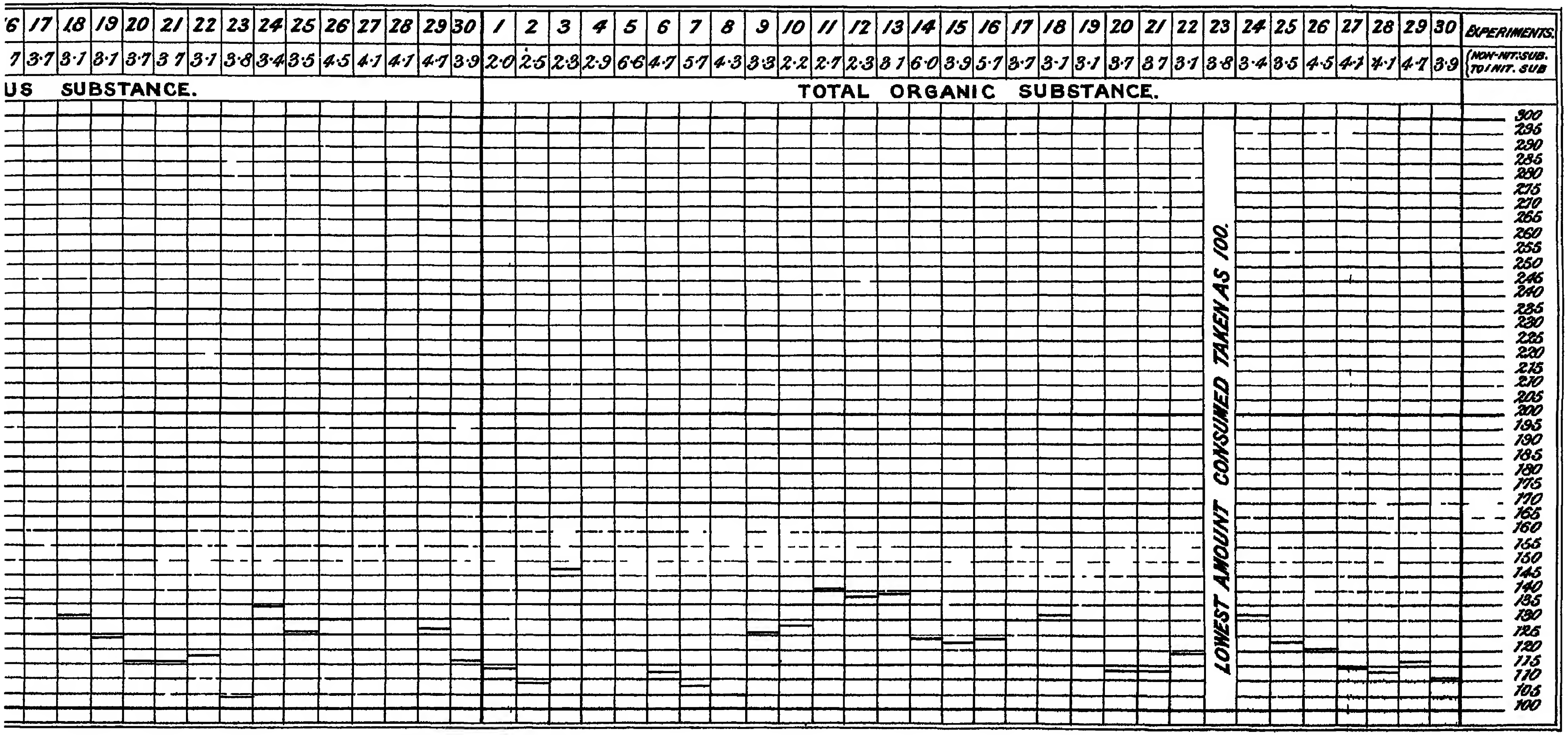
, *Animals fixed their own Consumption.*

" TOTAL ORGANIC SUBSTANCE, CONSUMED TO PRODUCE 100 LB. INCREASE IN LIVE-WEIGHT



# THE NITROGEN OF THE AIR IN RELATION TO P. ANT LIFE.[1]

By Dr A. P. Aitken.

It is related of the famous chemist Priestley that while walking one summer day in his garden he stopped opposite a little tank in which he kept fishes, and was surprised to see the leaves of the weeds in the water completely studded over with bubbles of gas which shone like diamonds in the sunlight. As he had been there feeding his little favourites only about an hour before, and had not noticed the bubbles, his curiosity was immediately excited to know what kind of a gas it was. That pretty phenomenon had been noticed by many thousands of people during many thousands of years, but no one ever thought of doing what Priestley did. He immediately hastened into the house for a bottle in which to collect the gas, and having got as much as he could, he tried some experiments with it, and was delighted to find that it was no other than the gas he had quite recently discovered, and to which he had given the name of "dephlogisticated air," but which was afterwards called oxygen.

### *Where did the Oxygen come from?*

The questions which naturally suggested themselves were, Where did the oxygen come from? Was it from the water or from the green leaves, or was it from some other gas dissolved in the water? Chemical science was not then so far advanced as to supply an answer. About twenty years previously a chemist in Geneva—M. Bonnet—had noticed the formation of air-bubbles in his aquarium, and taken an interest in the matter, and made some experiments in his own house. He found that the best water for showing the bubbles was spring-water, and that water which had been boiled showed none whatever. He naturally concluded that the bubbles were simply the air of the atmosphere, for he knew of no other gas, and that it had been dissolved in the water, and, separating itself from the water, had attached itself to the surfaces of the green leaves.

[1] Introductory lecture to the course of Agricultural Chemistry in the University of Edinburgh, 8th January 1895.

Priestley, some time before his discovery of oxygen, had made the curious observation that air which had become *depraved*, as he called it, by burning a candle in it or by breathing in it, could be made good again by keeping growing plants in it, and exposing them to sunlight.

### *It came from Carbonic Acid.*

It was left to Senebier, some years afterwards, to prove that the oxygen given out by plants came from the carbonic acid in the air or in the water in which they grew. At the beginning of this century the celebrated botanist De Saussure, as the result of a complete series of experiments, showed that not only did plants absorb the carbonic acid of the air and give out oxygen, but that they retained the carbon, and from it formed, if not all, at least a large proportion of the carbon of their tissues. During the seventeenth and eighteenth centuries it was the belief of the most advanced scientific men—such as Van Helmont, Boyle, Bonnet, and Duhamel—that plants were made from water; and it was quite natural that that opinion should prevail for a time, because it was a matter of common experience that when a seed was planted in a certain volume of soil, all that seemed necessary to enable it to grow to a plant many thousand times its own weight, and produce many hundreds of seeds, was that it should be supplied with water. The soil in which it grew did not seem to diminish in bulk, and only to what seemed an insignificant amount in weight, and the only thing which had to be supplied to it in abundant measure was water, pure water, even distilled water. That the solid matter of plants should be derived from liquid water was indeed a most wonderful transformation, but it was a far greater shock to the imagination to conceive that it was derived in great measure from the thin unsubstantial air.

### *Organic Matter from the Air.*

It is not surprising, therefore, to find that many of the most advanced investigators during the first half of the present century regarded with incredulity the amazing doctrine that the organic matter of plants was derived in great measure from the carbonic acid of the air; and the idea seemed all the more preposterous when the most careful investigations had shown that the amount of carbonic acid in the air was only a tiny and apparently insignificant fraction of the whole atmosphere. It seemed, therefore, most probable that the organic matter found

in the soil itself was the source from which plants derived their substance, and this opinion was much strengthened when it was found that the most fertile soils were those which naturally possessed, or to which had been applied, abundance of organic matter. Sir Humphry Davy, the first great chemist who in this country directed his attention to the chemistry of agriculture, was clearly of that opinion; and Albrecht Thaer, the first great authority on agriculture in Germany, based his system of rational agriculture on the principle that the great source of fertility lay in the humus or organic matter of the soil.

### *The Humus Theory of Plant Nutrition.*

He taught with great force, and with almost universal acceptance, the doctrine that organic matter was the product of organic energy; and while he accepted as far as he could the utility of carbonic acid as a nourisher of plants, he maintained that mere inorganic matter could not be the source of organic matter, but that the experience of agriculturists proved to him that the converse was more in accordance with facts. The doctrine that humus was the chief source of vegetable products appealed strongly to the minds of practical farmers also, as most in accordance with their practice and experience; but the investigations of chemists and botanists continued to furnish fresh proofs of the accuracy of the great truth whose discovery shed lustre on the closing years of the eighteenth century that the carbon of plants was derived from the carbonic acid of the air. It was not until about the middle of the present century that the fact became a popular possession, when Justus von Liebig had published his famous treatise on 'Organic Chemistry in its application to Agriculture and Physiology,' which appeared in Germany in 1840. In that remarkable work, whose publication forms the greatest epoch in the history of scientific agriculture, Liebig completely demolished the humus theory of plant nutrition, and laid the foundation of what has been called the "mineral theory." The manifold discussion and the bitter strife to which that publication gave rise, form an exciting chapter in the development of agricultural science.

### *Liebig's Cycle of Change.*

The only part of it which has to do with the subject on which I am now addressing you is that wherein he insists with all his wonted energy and fiery eloquence that the organic constituents of all organised beings, whether plants or animals, living on the

face of the globe, however complex may be their structure, are built up from the four elements—carbon, hydrogen, oxygen, and nitrogen; that the source of the carbon is the carbonic acid of the air; the source of the nitrogen is the ammonia of the air; and that in the death and decay of all animals and plants the final products are carbonic acid, water, and ammonia. The concluding words of one important chapter are those: "Carbonic acid, ammonia, and water contain in their elements the conditions necessary to the production of all the principles of living beings. These three bodies are the ultimate products of the putrefaction and eremacausis of all the races of animals and vegetables. All the products of vital energy, however numerous and however various, return eventually to the primitive forms in which they had their birth. Death, the complete dissolution of one generation, is always the source of a new generation."

The question which engaged the attention of chemists and physiologists towards the close of last century was the source whence plants derived their carbon. They found that it was the carbonic acid of the air, but it was half a century thereafter before their grand discovery received undisputed acceptance. The subject that has created the greatest amount of interest and given rise to the greatest amount of investigation during the present century is the source whence plants derive their nitrogen. We see from the paragraph I have just quoted that Liebig, about the year 1840, had quite made up his mind on the subject, and unhesitatingly affirmed that the one source of nitrogen for organised beings was the ammonia of the atmosphere.

### *Ammonia as sole Source of Plant Nitrogen.*

The mere trace of ammonia which, as carbonate chiefly, is found in the atmosphere, seemed to him at first too insignificant a store of nitrogen to supply the wants of the whole world's animal and vegetable life; but he was so impressed with the necessity for a complete harmonious cycle of change in the organic matter of the world, whereby that which was ammonia became converted into the constituents of animal or vegetable tissue, and that in turn reconverted into ammonia, that his philosophic mind could not be satisfied until he had argued himself into the notion that ammonia was the sole, and ought to be the sufficient, source of all organic nitrogenous compounds in the bodies of living beings. The estimates of the amount of combined nitrogen in the air, and in the precipitates from the air, including nitric and nitrous acid, which were available, seemed to him to provide as much nitrogen as ordinary vegetation required. He dismissed from his mind the idea that plants could

take any of their nitrogenous matter from the free nitrogen of the air, because he knew that nitrogen was the most indifferent among the elements, and naturally imagined that if plants could make use of free nitrogen, they would not exhibit, as they did, such an avidity for nitrogen in the form of ammonia salts.

It was well known at that time that the free nitrogen of the air was forced into union with oxygen during thunderstorms, for after a thunderstorm the rain was found to contain an unusual excess of nitric acid; but that was a violent process, not to be compared with the gentle, slow, vegetative processes of plant life. On the other hand, it was now the universally accepted belief that plants did in their chlorophyll cells decompose carbonic acid, and that is a process which, outside of the plant, is a difficult one to accomplish, requiring the application of a great amount of energy.

### *Can Plants utilise Free Nitrogen?*

That being so, it was natural to ask, Why might not the plant be able also to seize the free nitrogen of the air, and force it into combination with oxygen or hydrogen by means of some peculiar chemical reaction not prevalent in the inorganic world? The subject was one which formed an excellent field for debate, the weight of reason falling sometimes on one side and sometimes on the other; but as it was a subject concerning the facts of nature, no mere *a priori* reasoning could lead to any reliable result. It was entirely a matter for experiment.

### *Boussingault's Conclusion—Plants cannot assimilate Atmospheric Nitrogen.*

The first to carry out an investigation with this object in view, and fitted to produce results of any value, was Boussingault, who had for some years previous to Liebig's publication been engaged with his famous researches, which have since laid the sure foundation for a large part of the science of agriculture. He abandoned the eudiometric method that had been used by his predecessors, and which led to no certain result, and instead of estimating the amount of nitrogen in the air that had been in contact with the plant under experiment, he analysed the soil and the plant itself. He grew plants in an artificial soil containing no nitrogenous matter whatever, and in his later experiments he enclosed the plants and the pots in which they grew in a small chamber, into which no air was allowed to enter until it had been deprived of any trace of ammonia or other nitrogenous compounds, so that the plants

he operated on had no source of nitrogen available to them except the free nitrogen of the air. In the unnatural and unfavourable conditions under which the plants grew, the whole produce of the mature plants was only about two or three times the weight of the seeds from which they sprang, and it may be said in a sentence that, upon the whole, he found in the tiny crops grown no more nitrogen than was contained in the seeds which he had planted, and it mattered not whether he experimented with oats, beans, cress, or lupines. The smallness of the quantities of soil, of seed, and of crop, were such as to magnify inordinately any experimental error, but Boussingault was eventually so satisfied with the results of his researches that he had no hesitation in at length concluding that plants did not assimilate the free nitrogen of the air.

This opinion, definitely and repeatedly expressed by one who was justly regarded as the highest authority on such subjects, carried great weight, and received general acceptance, all the more readily as it was known that Boussingault at the beginning of his researches inclined to the opinion that plants could make use of free atmospheric nitrogen.

### *Ville's Conclusion—Plants can assimilate Atmospheric Nitrogen.*

In the year 1849 M. Georges Ville, director of the Agricultural Experiment Station at Vincennes, near Paris, began a long and laborious research on this most interesting subject. Accustomed to field experiments, he distrusted the results obtained by Boussingault. It seemed to him that plants which grew to be only two or three times the weight of the planted seed, and which had never really entered upon a natural independent state of existence, were not subjects from which to draw such a very sweeping and important conclusion. He managed his plants in such a manner as to enable them to attain a good normal growth. They were kept under cover, but well ventilated. The soil afforded them was abundant, and contained a certain definite amount of nitrate of soda, and the roots had plenty of room to increase, and they were also provided with good drainage and ventilation. The result was that his plants grew to be 10, 20, 50, or 100 times or more the weight of the seed, and in their substance they contained more nitrogen than was contained in the seed and the soil together. But as no other nitrogenous matter was allowed to have access to them except the free nitrogen of the air, which before entering the air-tight glass-case was deprived of ammonia, dust, or other impurities such as might interfere with the accuracy of the experiments, he came to the conclusion that plants, or at

least certain plants, could and did assimilate free nitrogen. Here were two authorities sharply at variance with each other, and, as sometimes unfortunately happens in what ought to be the calm atmosphere of scientific investigation, a storm arose. The scientific reputation of a distinguished member of the French Academy was assailed, and the matter was considered so important that the Academy accepted Ville's offer to appoint a Commission to examine his apparatus and superintend one of his experiments. Six distinguished *savants* formed that Commission, and the supervision occupied several months. Their report bore that M. Ville's conclusions were justified by the results he had obtained, but the Commission were not satisfied that the plants had not been supplied with ammonia as an impurity in the distilled water used for watering them. Ville ended his experiments in 1857, and in that year Messrs Lawes, Gilbert, and Pugh undertook a repetition of Boussingault's experiments at Rothamsted. In doing so they were exceedingly careful to avoid any errors into which Boussingault might have fallen, or rather to meet any possible objection that might be taken to any part of his operations. It is unnecessary to dwell here on such matters. It is sufficient to say that their results entirely confirmed those of the great French chemist.

With such weighty testimony against him Ville did not abandon his confidence in the accuracy and reliability of the results he had obtained. He was satisfied that the ammonia found by the Commission in that portion of the distilled water which had been preserved for analysis was not in the water at the time it was used to water his plants, but that it had been absorbed by it accidentally afterwards, so that the results of the experiment were in no way affected by that accident. He never abated his confidence in the accuracy of his work and the correctness of his conclusions; but in 1867 he published a new edition of his researches, and with the fuller knowledge born of eighteen years' experience in the growth and treatment of plants, he reviewed the work of Boussingault and of the English experimenters at Rothamsted, and it is of some importance to note the objections which he took to the Boussingault method.

### *The Defects of the Boussingault Method.*

He held that nothing but negative results could be obtained from the experiments, because

1. The air was too confined—not sufficiently often renewed—so that the plants suffered from want of ventilation.
2. The plants were usually sown at the wrong season of the year.
3. The quantity of soil in which they grew was quite inade-

quate, and prevented the roots and also the plants from attaining their normal growth.

4. Owing to deficiency of soil, the manurial matter—the mineral salt added to the soil—was too concentrated, and interfered with the development of the plants.

That all these are real defects of the method he was able to show by actual experiment. He maintained with increased vigour the futility of drawing any conclusions regarding the ability of plants to absorb free nitrogen from the air by studying the behaviour of a few misthriven specimens whose total weight was from two to four times the weight of the seed. In such circumstances he maintained they were never better than sucklings, dependent to the end of their days on the nourishment contained in the mother seed. Such plants could never be fairly compared with the plants of the field—such as oats, peas, beans, &c.—which produce a crop sixty and more times the weight of the seed. He also made an important statement, of the accuracy of which he gave some experimental proof—viz., that plants do not begin to assimilate the free nitrogen of the air until they have attained a stage of development in which they have acquired at least ten times the weight of the seed they grew from. He regarded that as the minimum of progress; but in some of the experiments recorded it was evident that a later stage of development had to be reached before the power of assimilating the free nitrogen of the air was acquired.

### *The Nitrogen-Assimilation Stage.*

In order that plants grown in an artificial soil may attain the development and vigour necessary to enable them to assimilate free nitrogen they must, according to Ville, be provided with a certain amount of nitrogenous food in the soil. Ville, therefore, added to the soils which he used not only the ordinary mineral matters used by Boussingault and by Lawes, Gilbert, & Pugh, but he added a certain small amount of nitrate of soda—viz., the amount which he considered sufficient to sustain the plant till it had attained that degree of development and vigour required to give it the power to assimilate free nitrogen. What that amount was depended on circumstances, but he showed that there was a certain minimum required, and he pointed out that there was also a certain maximum, not much exceeding the minimum, that must not be overstepped. If the amount of nitre did not reach the minimum, the plant never grew to proportions capable of enabling it to utilise free nitrogen. If the maximum were overstepped, the plant found in the nitre of the soil sufficient nitrogen for its needs, and it did not require to absorb atmospheric nitrogen. Evidently the plant found it

easier to assimilate nitre than to assimilate the free nitrogen of the air, and, as Ville says in the preface to the second edition of his published researches, "When a living creature finds in the sphere of its activity certain products which are equally capable of supplying its wants, and of which some are more easily assimilated than others, it begins by absorbing those whose assimilation is easiest." He therefore took care, in supplying nitrogen to his plants in the form of nitre, to give them just sufficient to tide them over the precarious part of their lives, and to leave them, when the supply of nitrogen from the nitre and the seed was used up, still with vigour enough to extract their further supply from the free nitrogen of the air.

I have referred at some length to Ville's experiments, conducted upwards of forty years ago and republished by the author about thirty years ago, because, although they were pretty generally discredited at the time, and their results were at variance with those of other more distinguished experimenters, they will be found, as I shall show hereafter, to be a remarkable anticipation of the most recent discoveries regarding the relation of plants to atmospheric nitrogen.

A few years ago no fact in the physiology of plant-life was more universally accepted than the entire inability of plants to assimilate any particle of that great ocean of nitrogen in which they are growing, and now I should think there is no one who has kept himself informed of recent research in that direction that doubts that some plants, at least, possess that power.

### *The Balance of Nitrogen.*

Although Ville's experiments failed to convince almost anybody, there nevertheless was a suspicion in the minds of chemists that there would be found some way by which the free nitrogen of the air became available to plants, if not directly, then indirectly. A general review of the fate of nitrogen on the surface of the globe led inevitably to the belief that there must be some very universally distributed means of forcing free nitrogen into combination in order that what has been called the "balance of nitrogen" might be maintained, for a more careful study of the decompositions of nitrogenous compounds had made it more and more evident that much of the combined nitrogen of the world was constantly being set free. When animal or vegetable substances are burned, or when they putrefy or decay, a certain amount of their nitrogenous matter is permitted to escape into the air as free nitrogen. It is not, as was supposed by Liebig, the inevitable fate of the organic nitrogenous matter of the world to become converted into

ammonia, and so to be immediately ready for reassimilation by plants into their various nitrogenous compounds.

*Loss of Combined Nitrogen by Decomposition.*

As far back as 1856 it was shown by Reiset that putrefying animal matter when enclosed in glass vessels gave up nitrogen, so that the air in the vessels contained from 1½ to 14 per cent more nitrogen than did atmospheric air. Ville found that on igniting sand in which seeds of lupine were buried, about one-third of the nitrogen of the seeds escaped as nitrogen gas. Schlösing, in 1873, found that nitrates when kept in soil, and in an atmosphere containing no oxygen, were reduced and gave up part of their nitrogen in the free state. Similarly, Gayon and Dupetit, in 1882, found that nitrates when brought in contact with diluted urine were reduced in the absence of oxygen and became partially converted into nitrogen, while simultaneously there was found a remarkable growth of micro-organisms. Dehérain and Macquenne in the same year noticed a similar reduction when nitrates were mixed with soil rich in humus, and in 1886 Tacke described experiments in which he found that in the alimentary canal of animals fermentations occurred which produced the same result, while Frank, in 1884, found that soils rich in humus and to which nitrates had been added lost nitrogen to the extent of from 5 to 12 per cent of their total nitrogen, which escaped in the free state when ventilation was restricted.

From a purely chemical standpoint it is known that when amines or amides, or similar substances, come in contact with nitrites, a decomposition occurs in which nitrogen gas is set free, and as these substances are found in the soil and in places where large quantities of organic matter are decomposing and subjected to the action of air, it is natural to suppose that much combined nitrogen may be lost to agriculture in that way. The extent of that source of loss is far from being established, but it is one of the ways in which a great loss of nitrogen may occur.

*Loss of Combined Nitrogen by Drainage.*

Apart from the sources of loss referred to as certain or as probable, there has to be taken into account the great loss to the land of combined nitrogen in the constant washing out of nitrates from the soil by rain, which carries them down the river-courses into the sea. The thorough drainage which forms so important a part of modern agriculture assists greatly in increasing this source of loss. Nitrates and ammonia salts are found in almost all river-waters, and unless there were operat-

ing some means by which the combined nitrogen lost to the land were recouped, it is evident that vegetation must become more and more deprived of one important element of its fertility.

General considerations such as these, supported by experimental evidence of a perfectly satisfactory kind, in a great many cases made it evident that by many known and also presumably by many unknown ways the amount of combined nitrogen on the globe must be annually suffering serious diminution unless there were some converse compensating processes at work.

*Conversion of Free into Combined Nitrogen.*

That there must be such compensation was evident from a wide survey of the history of vegetation on the globe. A study of the earth's crust informs us that there was a time when this planet was a molten mass on which there was no vegetation, and now it is covered with it as with a mantle. That vegetation should have grown and increased to such dimensions, implies that the ammonia of the atmosphere must at one time have been very abundant and be constantly diminishing, or that there must be some means by which free nitrogen is being abundantly converted into nitrogenous organic matter.

It was at one time thought that the great source of this conversion was found in the formation of ammonium nitrite during the mere evaporation of water on the earth's surface, and it was the cause of some disappointment when this theory of Schonbein was discovered to be founded on error. The formation of nitrite and nitrate in the air during thunderstorms I have already referred to, and similar combinations due to the action of ozone have been observed. Other means of causing nitrogen to go into combination by chemical processes operating on the surface of the earth have been suggested, and in most cases found untenable. It is unnecessary to refer to any of these at this time. It is sufficient to observe that the combined nitrogen of the atmosphere and any other sources available were not regarded as sufficient to compensate more than a small part of the loss of combined nitrogen by the processes already referred to, and it became evident, the more the history of the circulation of nitrogen on the earth was considered, that in order to maintain the balance of nitrogen some universal method by which free nitrogen is brought into combination must be going on on the surface of the globe, and the action of plant-life was the one to which one naturally turned in order to find it.

It had been known for many centuries that the growing of leguminous crops was a means of enriching the land in such a manner that after clover, vetches, or the like, an increased yield of wheat or other cereal crop could be obtained; and since

chemistry has come to the aid of agriculture, it has been discovered that the reason why leguminous crops favour the growth of succeeding cereals is that they leave the soil richer in nitrogenous matter than it was before, and this despite the fact that the leguminous crops themselves are distinguished among all other crops by the large amount of nitrogenous matter they contain.

*Schultz, Lupitz.*

A very important experiment, that did more than any other to bring home this truth to the minds of agriculturists, was the system employed by Herr Schultz on his property of Lupitz in Altmark. He came into possession of his property in 1855, and endeavoured to grow crops on the poor light soil characteristic of the district. He had a very discouraging experience at first, for his land was so poor that it could not grow oats, and in order to grow a fair crop of rye he had to adopt the system of green manuring. He grew lupines the one year, and ploughed them in, and then grew rye the next year. He found that his land was deficient in lime, and he applied marl to a large part of it, and found that the lupines grew all the better for it. He also applied superphosphate and kainit, of which great stores had just been discovered in his neighbourhood. In doing these things he was following the teachings of Liebig, and he was surprised to find that the lupines responded wonderfully to the application of the Liebig manures, so that year by year the amount of his crops increased. He sometimes cut his lupine crop for fodder, and sometimes ploughed it in; but whether he adopted the one course or the other, the land which had formerly been so barren improved every year, and year by year grew richer in nitrogen, although he had never applied to it any nitrogenous manure whatever.

*Nitrogen Collectors and Nitrogen Consumers.*

He grew many other leguminous plants besides lupines, and found that they had the same fertilising effect, though in a less degree. He classified his crops under two heads—"nitrogen collectors," which included the leguminous crops, and "nitrogen consumers," which were the cereal crops—and although it is now forty years since the system began, it is still being continued. Large crops are annually taken off the ground rich in nitrogenous matter, and yet the soil is yearly increasing in nitrogen. Unfortunately the soil was not analysed when the experiments began, as they were not undertaken for scientific purposes; but there is plenty of unimproved land in the neighbourhood quite like that upon which Schultz began, and analyses

that have been made of it show quite conclusively that his land is thrice as rich in nitrogen as it was when he began to work it. These experiments of Schultz (Lupitz) tell us nothing about the source of the nitrogen except that it came from the air, but whether it was the ammonia of the air or ordinary atmospheric nitrogen could only be matter of conjecture. Considering, however, the smallness of the store of atmospheric ammonia, and that leguminous plants under manurial treatment show no liking for ammonia salts of any kind, and are apt to be the worse rather than the better for them, even when applied in quantity ten times less than the equivalent of that contained in the crop, it seemed in the highest degree probable that the source of the great gain of nitrogenous matter must be sought for in the free nitrogen of the air.

The remarkable effects produced by growing lupines and other leguminous plants at Lupitz required to be studied from some other point of view than the merely chemical one.

### *Schlosing and Muntz's Discovery of Nitrification.*

The notion that micro-organisms were intimately associated with the growth of plants, and the chemical processes in the soil that were favourable thereto, had been made familiar by the discovery of the fact that the conversion of nitrogenous matter in the soil into nitric acid was achieved by living organisms. The credit of that brilliant discovery belongs to two French chemists (Schlösing and Muntz), who published their first report of it in 1877. It has worked nothing short of a revolution in our method of viewing the relations of the soil to plant life. Mr Warington, who was studying the question of nitrates in the soil at Rothamsted at that time, found in it the key to much that was difficult to understand in the history of the Rothamsted drainage. He set about studying and investigating the conditions of nitrification by means of the nitrifying organism, and although he had not been able to find the organism itself, he was able to ascertain a wonderful amount of knowledge regarding the conditions of its life and its general behaviour.

### *The Nitrifying Organism.*

Meantime Winogradsky, Frankland, and Warington were all engaged in different ways hunting for the nitrifying organism in order to obtain a pure cultivation of it; and the method employed, and the ingenuity displayed, by these investigators, form quite a romantic chapter in the history of agricultural research. It was found by Winogradsky that this organism

differed from all others previously studied, in that it required no organic matter for its growth; and as all attempts to grow it on organic jellies had failed, he invented a method which will doubtless be adopted with success hereafter in similar investigations. He isolated the organism in 1890 by making cultivations on the surface of gelatinous silica containing the necessary amount of inorganic food. It will be my duty at a future period to inform you specially regarding these investigations, which I merely mention now incidentally as showing that from 1877 onwards a new light has been shed upon the chemistry of the soil and of plant growth generally, and a biological, as distinguished from a purely chemical, method has been pointed out, by means of which such questions as the ability of plants to assimilate free nitrogen may be investigated.

### *Hellriegel and Wilfarth's Discovery.*

Hellriegel and Wilfarth, fully appreciating the value of the biological method, studied the lupine and other Papilionaceæ, paying particular attention to the small tubercles which had been long ago observed in the roots of that sub-order of plants. A microscopic examination of the tubercles showed that they contained bacteria and a mass of bodies somewhat resembling bacteria, and hence called bacteroids. If these were living organisms resident in the plant, they might perhaps be found to have had their origin in the soil, and to be using the roots of leguminous plants simply as a host. That was easily determined by growing seeds, say, of lupine in sterilised soil, when it was noticed that no tubercles then made their appearance. When, however, the plants were grown in a sterilised soil to which a few cubic centimetres of the washings of an unsterilised soil were added, the tubercles were developed. The next point to determine was what specific effect these tubercles, or rather the bacteroids within them, had upon the growth of the plant. By means of many experiments they arrived at most interesting and important results, which Professor Hellriegel communicated to the Agricultural Section of the German Naturalists at Berlin on 20th September 1886, Dr Gilbert of Rothamsted presiding.

### *Nitrogen Assimilation from a Biological Standpoint.*

The gist of that communication, which marks an epoch in the history of agricultural science, was that when cereals and leguminous plants were grown in a sandy soil to which the requisite

mineral manures were added, and the nitrogenous matter given in the form of nitrate, the cereals made growth and attained vigour in direct proportion to the amount of nitrate given to them when the amount provided was small; so that a double dose of nitrate caused the growth of a twofold amount of organic matter, a treble dose gave a threefold increase, and so on until that amount of nitrate had been added which enabled the plants to grow to their normal size, when, of course, the further addition of nitrate had less and less effect upon the amount of organic matter produced. The cereals were able to assimilate the nitrates *directly*, and their growth in a soil otherwise fertile depended precisely upon the amount of nitrate present. With the leguminous plants no such correspondence was observed. Their growth was quite capricious, and, indeed, sometimes the soil containing the least amount of nitrate produced the largest and healthiest plants. It seemed from many experiments that leguminous plants—such as peas, clover, and lupines—were very little dependent on the nitric acid of the soil for their nitrogenous nourishment.

### *Papilionaceæ assimilate Free Nitrogen.*

That being so, it must be atmospheric nitrogen, either combined or free, that must be looked to as the source of the nitrogen supply of at least that order of plants. I need not refer in detail to the many experiments recorded by which Hellriegel and Wilfarth came to the conclusion that it was the free nitrogen of the air that formed the store from which leguminous plants derived their nitrogenous nourishment. They found that the ability of that order of plants to assimilate free nitrogen was associated in some way with the tubercles in their roots. Lupines which were grown in sterilised soil, but provided with all the elements of fertility, might grow well enough, but the crop produced contained no more nitrogen than had been provided in the soil and in the seed, and their roots contained no tubercles. On the other hand, when grown in a soil containing very little nitrogen, but in which the micro-organisms associated with the growth of tubercles were present, it was noticed that the plants grew to a certain stature and then began to droop. Cereals grown under similar conditions presented a similar appearance, and eventually died down; but in the case of the lupines, after passing through the drooping stage and losing some of their leaves, they revived, shot out new leaves, and grew at length to full stature. When the crop was analysed, and also the soil in which it had grown, it was found that there was a

notable increase of nitrogen in both. This is precisely what Georges Ville found in his experiments thirty years before, and which he described to an incredulous world, and the conclusion he arrived at was the same—viz., that leguminous plants are able to utilise the free nitrogen of the air in building up their tissues.

Since the publication of Hellriegel and Wilfarth's researches, many other investigators, and among them Lawes and Gilbert at Rothamsted, have repeated the experiments, and have confirmed the accuracy of the results obtained. It may seem strange that, after the lapse of a quarter of a century, experiments designed to prove whether plants, including Leguminosæ, assimilate free nitrogen, should have brought the experimenters to such an entirely opposite result; but it must be remembered that in their recent work they had the advantage of looking at the question from the standpoint of biology rather than that of chemistry. Georges Ville did not suspect the agency of micro-organisms in producing the results he recorded. Had he done so, it is probable that the inherent defect of Boussingault's methods would have been apparent, and good heed would have been paid to the objections which Ville raised against them. As it happened, his objections were disregarded, and we were left for a generation without the advantage which a full acknowledgment of the accuracy of his observations would have achieved for agricultural science. The fact that the discovery of Hellriegel and Wilfarth has confirmed the accuracy of Ville's experiments, and that this important conclusion was anticipated by him, in no way diminishes the credit due to them for their independent discovery, or the obligations under which agriculturists have been put in having a new path of progress opened up to them. What that path is, and how it may be pursued in the operations of agriculture, and how important must be the effect of it in agricultural practice, I shall have to speak to you hereafter. I am glad, however, to have had the opportunity of bringing once more to notice the laborious research of M. Georges Ville, in order that it may receive the consideration which it deserves, and that we may do some homage to his memory as a small reparation for the distrust, opposition, and I might almost say abuse, which the publication of his researches on the assimilation of free nitrogen brought upon him.

Since the publication of Hellriegel and Wilfarth's paper in 1886, an immense amount of interest has been taken in the growth of leguminous plants. The conditions under which the tubercles are formed, the method of their formation and development, the relation of their abundance to the growth and vigour of the whole plant, the connection between them

and the power of assimilating free nitrogen, and many other collateral questions, have engaged, and are now engaging, the attention of vegetable physiologists. As is to be expected, crude views are constantly being expressed and being opposed, and out of the multitude of contradictory experiences and opinions it is difficult to sift those which are trustworthy from those which are not. I would only remark here, that while the fact that leguminous plants do assimilate free nitrogen seems to be abundantly proved, the place where the assimilation occurs, and the conditions under which it occurs, are as yet matters of conjecture. I will just refer in closing to one or two authorities of first importance, giving the views which they entertain as the result of very thorough investigation.

I have said that Hellriegel and Wilfarth have been led to the conclusion that leguminous plants differ from others in that they are provided with tubercles on their roots, which are the seat of changes due to micro-organisms whereby albuminoid matter is stored up from the assimilation of free nitrogen from the air of the soil or of the atmosphere; but whether the bacteria coming from the soil, or the bacteroids developed under their influence in the tubercles, are the actual bringers of nitrogen to the plant, or whether they stimulate the plant in such a way as to enable it to take up free nitrogen by its leaves or otherwise, they have no experimental evidence to determine.

### *Papilionaceæ not the only Assimilators of Free Nitrogen.*

Berthellot, in conjunction with André, has been for a long time engaged in similar investigations, the result of which is that he has proved that, altogether apart from the growth of leguminous plants, some *soils* are capable of absorbing the free nitrogen of the air. In such cases the gain in nitrogen is caused by a growth of organic matter, and he has been able to show that it is due to the presence of small unicellular algæ that the enrichment takes place.

Professor Frank, of Berlin, who has devoted years of study and investigation to the subject, has come to the conclusion that the tubercles on the roots of leguminous plants are not the cause of their ability to absorb free nitrogen, but they are rather the result of that process. He is of opinion that it is only when the plant, as Ville showed long before, has attained a certain amount of vigour of growth that it can make use of the free nitrogen of the air, and it is only when that stage has been attained that the tubercles on the roots which had been long dormant begin to attain important dimensions.

### *The Seat of the Assimilation of Free Nitrogen.*

He accepts the theory, or rather the conclusion, of Berthellot, that small cryptogamic plants, such as algæ, are able to assimilate free nitrogen, and that the organic nitrogen in the soil is due in some measure to their growth; but he sees in unicellular algæ small plants that may be compared with the ordinary chlorophyll-cells of green-leaved plants in general, and he is of opinion that the seat of the assimilation of free nitrogen is to be found in the chlorophyll-cells, where it has been long ago proved that the seat of the decomposition of carbonic acid and the fixation of carbon takes place. He makes no differentiation between leguminous plants and others as regards their ability to assimilate free nitrogen in their chlorophyll-cells, while he acknowledges that that order of plants possesses the power in a very remarkable degree. He is therefore of opinion that while fallow land, poor in organic matter, may become richer in nitrogen through the growth and nitrogen assimilation of minute cryptogams therein, that enrichment is greatly augmented when plants of a higher order are grown upon the land. Some orders of plants, like Leguminosæ, may assimilate so much nitrogen from the air as to leave in their roots and stubble when the crop is removed more nitrogen in the form of nitrogenous organic matter than was there previously; others, such as cereals, may assimilate so little atmospheric nitrogen, and make at the same time such demands upon the nitrates in the soil, as to leave the land poorer when the crop is removed. Between these extremes come all manner of crops, all of which, especially in the later stages of their growth, do assimilate free nitrogen; but whether the amount so assimilated will cause them to be ranked agriculturally as nitrogen collectors or nitrogen consumers depends upon the greater or less extent of their leaf-surface, and the consequent multitude of chlorophyll-cells exposed to the air, and probably also to specific differences in the ability of the chlorophyll-cells of some Orders of plants to assimilate free nitrogen in comparison with others.

These views of Frank are combated by many distinguished chemists and botanists, and though they are eminently reasonable, and hence attractive and satisfactory from a philosophic point of view, nothing but actual proof derived from trustworthy experiment will in these days secure their acceptance.

I hope to have the opportunity hereafter to examine with you critically the foundations on which rest the opinions held regarding the manner in which plants come by their nitrogen.

What I have endeavoured to do to-day is to take a general

survey of the question, treating it from a historical point of view. At the end of last century it was the splendid achievement of the scientists of that time to show how it was that plants were able to acquire their carbon, and a later and more comprehensive survey of the conditions of life upon the globe showed how animals and plants were associated in the alternations of oxidation and reduction in which that element took part. It would seem that at the close of the present century we are on the eve of solving the still more difficult problem of the history of nitrogen as it fluctuates between what are known as the organic and inorganic dominions of matter upon the earth's surface.

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# THE CEREAL AND OTHER CROPS OF SCOTLAND FOR 1894, AND METEOROLOGY OF THE YEAR RELATIVE THERETO.

## THE CROPS.

THE following comparison of the cereal and other crops of 1894 with those of the previous year, has been prepared by the Secretary of the Society from answers to queries sent to leading agriculturists in different parts of the country.

The meteorology of the year has been furnished by Dr Alexander Buchan, Secretary of the Meteorological Society of Scotland.

The queries issued by the Secretary were in the following terms:—

1. What was the quantity, per imperial acre, and quality of grain and straw, as compared with last year, of the following crops? The quantity of each crop to be stated in bushels. What quantity of seed is generally sown per acre?—(1) Wheat, (2) Barley, (3) Oats.
2. Did the harvest begin at the usual time, or did it begin before or after the usual time? and if so, how long?
3. What was the quantity, per imperial acre, and quality of the hay crop, as compared with last year, both as regards ryegrass and clover respectively? The quantity to be stated in tons and cwts.
4. Was the meadow-hay crop more or less productive than last year?
5. What was the yield of the potato crop, per imperial acre,

as compared with last year? The quantity to be stated in tons and cwts. Was there any disease? and if so, to what extent, and when did it commence? Were any new varieties planted, and with what result?

6. What was the weight of the turnip crop, per imperial acre, and the quality, as compared with last year? The weight of the turnip crop to be stated in tons and cwts. How did the crop braird? Was more than one sowing required? and why?
7. Were the crops injured by insects? State the kinds of insects. Was the damage greater or less than usual?
8. Were the crops injured by weeds? State the kinds of weeds. Was the damage greater or less than usual?
9. Were the pastures during the season of average growth and quality with last year?
10. How did stock thrive on them?
11. Have cattle and sheep been free from disease?
12. What was the quality of the clip of wool, and was it over or under the average?

From the answers received, the following notes and statistics have been compiled:—

EDINBURGHSHIRE. *Wheat.*—About 40 bushels; quality not so fine as last year; straw about the same; 3 bushels seed sown.

*Barley.*—About 40 to 44 bushels; quality not so fine as last year; 3 bushels seed sown.

*Oats.*—About the same as last year; 48 bushels; quality not so fine; straw about the same; seed sown, 4 bushels.

*Harvest* commenced 28th August, two weeks later than last year.

*Hay.*—Very heavy crop, and well secured; 3 tons 10 cwt.; fine quality. Second crop very good, but not so well secured. *Meadow-hay*—More productive than last year, and well got.

*Potatoes.*—Not so heavy a crop as last year, and quite free from disease. Regents the heaviest crop of the season, about 7 to 8 tons; about 2 tons more than Bruce or Maincrop.

*Turnips.*—Scarcely so heavy a crop as last year; quality very good. Yellows, about 25 tons; swedes, about 20 tons. Only once sown, except in cases where they were frosted down.

No damage from insects. Weeds were more prevalent than in former years. Dokens was the most troublesome weed, especially in the oat crop.

*Live Stock.*—Pasture fully as good as last year. Stock throve and fattened well, and were quite free from disease. *Clip of wool*—About the average; prices rather lower than former years.

LINLITHGOWSHIRE. *Wheat.*—Less in quantity and not so good in quality as compared with last year; from 25 to 35 bushels; seed from 2½ to 3 bushels.

*Barley.*—Less in quantity and not so good in quality as compared with last year; from 25 to 35 bushels; seed from 2½ to 3 bushels.

*Oats.*—Less in quantity and quality of both grain and straw; from 25 to 35 bushels; seed, from 4 to 6 bushels.

*Harvest* began and ended a month later than last year.

*Hay.*—Better in quantity, but not so good in quality as last year; from $1\frac{1}{2}$ to 3 tons. *Meadow-hay*—Good, but very little grown in the district.

*Potatoes.*—Not so good in quantity or quality as last year; some disease in the early sorts; from 3 to 6 tons.

*Turnips.*—Very variable; some places good, others almost a failure; very little second sowing.

No injury by weeds or insects.

*Live Stock.*—Pastures of average growth and quality. Stock throve well and were free from disease. *Clip of wool*—Good, and about an average.

HADDINGTONSHIRE (Upper District). *Wheat.*—None grown.

*Barley.*—30 to 32 bushels, of poor quality; grain and straw damaged by wet weather; 3 bushels sown.

*Oats.*—36 bushels; not so good as last year; damaged by rain in harvest; 4 bushels sown.

*Harvest* began on 6th September 1894, a month later than in 1893.

*Hay.*—$2\frac{1}{2}$ tons, of good quality. *Meadow-hay*—A good crop.

*Potatoes.*—7 tons; about same as last year. Regents very much diseased; Magnums and Maincrops free from disease, but small. No new varieties planted.

*Turnips.*—17 tons, of fair quality; crop brairded well; only one sowing.

No injury done this year by insects. Very few annual weeds, and fallow-land well cleaned.

*Live Stock.*—Pastures were of better growth than last year, and stock did very well on them, and were free from disease. *Clip of wool*—About an average.

HADDINGTONSHIRE (Lower District). *Wheat.*—5 quarters, or about the same as last year; quite as much straw of good quality; $3\frac{1}{2}$ bushels sown.

*Barley.*—40 to 44 bushels, or rather more than last year; not so good quality; more straw than last year; $2\frac{1}{2}$ bushels sown.

*Oats.*—44 to 48 bushels, or rather more than last year; fine quality; more straw; 4 bushels sown.

*Harvest* began about 20th August, or a fortnight later than last year.

*Hay.*—$2\frac{1}{2}$ tons, quite a ton more than last year; fair mixture of rye-grass and clover. Weather rather broken, but it was all fairly well got.

*Potatoes.*—6 tons; no disease in later varieties, but some in Regents; not many of them grown now.

*Turnips.*—20 tons; quality not so good as last year, owing to many being early sown and inclined to run to seed.

No injury by insects or weeds.

*Live Stock.*—Pastures rather better than last year; as regards growth, quality scarcely so good, on account of wet season. Stock did fairly well. No disease in cattle; foot-rot very bad in sheep owing to wet summer. Full average clip; good quality.

BERWICKSHIRE. *Wheat.*—29 bushels; more straw; seed, 3 bushels.

*Barley.*—37 bushels; straw above average; seed, $2\frac{1}{2}$ bushels.

*Oats.*—40 bushels; corn and straw under average for quality; seed, $4\frac{1}{2}$ bushels.

*Harvest* late, 28th August.

*Hay.*—1 ton 5 cwt.; the early-cut hay was good quality, late-cut hay much damaged. *Meadow-hay*—Poor crop, and much damaged.

*Potatoes.*—$4\frac{1}{2}$ tons; quality good; no disease.

*Turnips.*—18 tons; brairded well; no resowing.

No injury by insects or weeds.

*Live Stock.*—Pastures better than last year. Stock throve well, and were free from disease. *Clip of wool*—Average.

ROXBURGHSHIRE. *Wheat.*—About 32 bushels; quality good; very little grown in the district.

*Barley.*—30 bushels; quality inferior, and under average bulk of straw.

*Oats.*—35 bushels; what was early, quality good, late much damaged; straw under average bulk.

*Harvest* about ten days later than usual.

*Hay.*—Quantity about 28 cwt.; quality not quite so good as last year. *Meadow-hay*—A bulky crop, and generally well got.

*Potatoes.*—Scarcely an average crop; about 4½ tons marketable; not much disease; mostly Maincrop Kidney grown, and no disease among them.

*Turnips.*—Under an average; brairded well; a good many fields diseased; not more than 17 tons.

Little or no damage by insects. Almost no weeds but thistles.

*Live Stock.*—Pastures fully average growth. Sheep did well. Cattle and sheep free from disease. *Clip of wool*—Rather under average, but quality good.

SELKIRKSHIRE. *Wheat.*—None grown.

*Barley.*—30 bushels; quality inferior; dark colour, and a good deal of heating in the stack; the clover was very rank, and helped the discoloration; between 3 and 4 bushels sown.

*Oats.*—33 bushels; quality not nearly so good as last year. On the higher lands crop was cut very green, and a great acreage was gathered in very bad order, fit only for feed, and not of much account for that. Seed sown, 4½ bushels.

*Harvest* about ten days after the usual time.

*Hay.*—Much heavier crop than last year; would weigh from 2 to 2 tons 10 cwt., and quality equal to last year. *Meadow-hay*—Much more productive; quality good.

*Potatoes.*—Crop much the same as last year—about 7 tons; no disease; varieties much the same.

*Turnips.*—14 tons; much less weight than last year; quality quite as good; crop brairded fairly well; no second sowing. Kept three weeks off the land in spring with wet, consequently turnips very late.

No damage by insects. No damage to speak of by weeds.

*Live Stock.*—Pastures of more growth than last year; quality not quite so good. Stock throve fairly well, and were free from disease. *Clip of wool*—Under average.

PEEBLESSHIRE. *Oats.*—36 bushels; quality of grain and straw not so good as last year; seed sown, 5 bushels.

*Harvest* a little later than usual.

*Hay.*—Ryegrass, 35 cwt.; meadow-hay, 30 cwt.; quality not so good as last year. *Meadow-hay* crop—More productive.

*Potatoes.*—Yield, 6 tons; more last year; very little disease.

*Turnips.*—Weight, 15 tons; quality good, better than last year; crop brairded well, but in some cases was injured by frost; one sowing.

No injury by insects or weeds.

*Live Stock.*—Pastures more luxuriant than last year. Stock throve very well. Cattle and sheep were free from disease. *Clip of wool*—Good; average.

DUMFRIES (Upper Nithsdale). *Wheat.*—Not grown.

*Barley.*—Not grown.

*Oats.*—27 bushels, with average straw; quality superior where successfully harvested.

*Harvest* earlier by ten days; weather dry and sunny, but without wind, consequently much grain heated in the stack.

*Hay.*—Ryegrass a good crop, 1¾ ton; strong grown, and secured in fair condition; clover abundant in the hay, but entirely absent in the aftermath, which was very poor. *Meadow-hay*—More productive than last year, and generally of prime quality.

*Potatoes.*—A smaller crop, about 4 tons; free from disease, and of good quality, though later varieties deficient in size.

*Turnips.*—Average crop, 15 tons; brairded well, and no resowing required, except where very early sown and the braird frosted.

Insects did little damage. Favoured by the mild winter and early spring, grass grew abundantly in the oat crop and greatly checked its growth, pearl-grass being much in evidence. Rain prevented the use of the horse-hoe amongst turnips after singling, consequently an abnormal growth of weeds—twitch, wild mustard, and redshank.

*Live Stock.*—Pastures over an average and usually early, also affording a full bite for stock far into autumn. Stock throve well, especially sheep. Cattle free of disease; but sheep much afflicted with lameness, probably caused by the roughness of the pasture. *Wool*—Over an average, and quality good.

KIRKCUDBRIGHTSHIRE. *Wheat.*—33 bushels; quality not equal to last year; straw more than last year; seed about 3 bushels.

*Barley.*—34 bushels; quality good; straw considerably more; seed, 3½ to 4 bushels.

*Oats.*—35 bushels; quality not so good as last year; straw 25 per cent more; quality very good; seed, 4 to 5 bushels.

*Harvest* about the usual time.

*Hay.*—30 to 32 cwt., much over last year; quality, some very good, some much spoiled by weather. *Meadow-hay*—50 per cent more.

*Potatoes.*—Various, 3 to 10 tons; on the whole much under an average, say 4 tons; very little disease; no new varieties.

*Turnips.*—16 tons; quality good; good braird. Crop much checked by dry weather of August and September; after rain came an immense increase of crop. No resowing.

No injury by insects. More weeds than usual, owing to wet weather.

*Live Stock.*—Pastures of average growth and quality. Stock throve extra well, and were free from disease. *Clip of wool*—Fully an average.

WIGTOWNSHIRE. *Wheat.*—27 bushels, being 2½ bushels less than last year; quality 2 lb. less per bushel; straw same as last year; seed sown, 2½ to 3 bushels.

*Barley.*—30 bushels, being 1½ bushel more than last year; quality 1½ lb. per bushel less than last year; colour not so good, owing to want of sunshine; straw 20 per cent more than last year; seed sown, 3 to 3½ bushels.

*Oats.*—40 bushels this year, being 1½ bushel better than last year; quality 2 lb. per bushel more than last year; straw 20 per cent more than last year; seed sown, 5 bushels.

*Harvest* fourteen days later.

*Hay.*—48 cwt. this year, last year about 35 cwt.; quality same as last year. *Meadow-hay*—1¾ ton this year, against 1⅓ ton last year.

*Potatoes.*—3 tons, being a large reduction from last year; disease same as in former years, but more pronounced; no new varieties planted.

*Turnips.*—14 tons, being under last year's crop; braird good; very little second sowing required.

No insects to speak of; less damage than usual. In early part of season considerable rush of ordinary weeds, but not appreciably different from other years.

*Live Stock.*—Pastures much more abundant than last year, but scarcely so good in quality. Stock throve very well, and were entirely free from disease. *Clip of wool*—5 per cent better than last year; a fair average clip.

AYRSHIRE. *Wheat.*—Fair average, about 32 bushels; not much grown.

*Barley.*—Average about 36 bushels; not much grown.

*Oats.*—A good crop, 48 bushels; an average crop for earliness.

*Harvest* just about the average time.

*Hay.*—Above an average, fully 2 tons. *Meadow-hay*—Full average; not very well got.

*Potatoes.* — About an average; early one full, late not average; no disease to any extent.

*Turnips.*—Not an average; it brairded well, but too much rain in July and August.

Not much damage by insects. Rather wet weather; not easily kept clean.

*Live Stock.*—Pastures above an average, and fine quality of grass. Stock throve very well. Cattle and sheep generally free from disease. *Clip of wool*—A good average.

BUTE. *Wheat.*—None grown.

*Barley.*—About 28 bushels; grain light and straw inferior, due to wet season; seed sown, 4 bushels.

*Oats.*—About 36 bushels; grain and straw of inferior quality; seed sown, 5 to 6 bushels.

*Harvest* commenced on 28th August, about the usual time; over very soon, but a number of stacks heated.

*Hay.*—Crop below the average, about 2 tons; well got in. *Meadow-hay*—Little of this crop in island; but what was of it was an average crop.

*Potatoes.*—Uneven crop. Early potatoes were to a large extent frosted, while the later were better. Yield about 6 tons; not much disease this year; no new varieties of consequence.

*Turnips.*—Under average, from 10 to 20 tons; crop brairded well; no resowing.

No injury of consequence by insects. More weeds than usual, and of the usual kind, owing to wet season.

*Live Stock.*—Pastures about an average. Stock throve fairly well, and were free from disease. *Clip of wool*—Fair average.

ARRAN. *Wheat.*—None grown.

*Barley.*—None grown.

*Oats.*—About 35 bushels; larger bulk of straw; deficient in quantity and quality of grain; seed sown, about 6 bushels.

*Harvest* began about usual time, two weeks later than last year; crops secured in excellent condition.

*Hay.*—About 28 cwt.; more clover; deficient in weight and quality from last year. *Meadow-hay*—Little grown.

*Potatoes.*—About 5 tons; small crop from last year, with a large proportion of undersized; Champion variety mostly grown; not much disease.

*Turnips.*—About 18 tons; early-sown fields badly mildewed on light

soils; swedes improved on deep land till December; brairded well; crop fully one-third less than last year.

No injury by insects. More weeds than last year.

*Live Stock.*—Grass more plentiful, but quality not so good. Stock throve fairly well. Cattle and sheep very free from disease. *Wool*—Fair quality; quantity rather less, with a reduction in price.

Lanarkshire (Upper Ward). *Wheat.*—None.

*Barley.*—Almost none grown in district.

*Oats.*—About 36 bushels, or 4 bushels less than last year; quality about same as last year, unless portions that were indifferently secured owing to mild weather.

*Harvest* began about the usual time for this district, but three weeks later than last year.

*Hay.*—Rather over last year, but clovers considerably damaged in many cases by wild pigeons in the autumn and spring months; quality excellent.

*Meadow-hay*—About 25 per cent better than last year; quality good.

*Potatoes.*—4 to 5 tons less than last year; quality good; almost no disease, having been checked early by frost. Maincrop variety finding favour in this district, although not so heavy croppers as the Regents.

*Turnips.*—18 to 24 tons; brairded well, but a good proportion of the early sown ran to seed; a good deal of finger-and-toe in some parts; difficult to get cleaned owing to wet.

No leaf-insects. Not much injury by weeds unless in small wet portions or indifferently drained land.

*Live Stock.*—Pastures rather over the average. Stock throve well, and were free from disease. *Clip of wool*—Quality good, rather over the average.

Lanarkshire (Middle Ward). *Wheat.*—40 bushels, fine quality; about 2 tons straw, fine quality; seed from 3 to 4 bushels.

*Barley.*—Little grown in this district.

*Oats.*—Good crop, yielding 40 bushels; fine quality; straw more than previous year, about 1½ ton; seed sown, 4 to 5 bushels.

*Harvest* three to five weeks later than last year; weather fine.

*Hay.*—Ryegrass good crop; yield 1½ to 2 tons; quality fine. Timothy, 2½ to 3 tons. *Meadow-hay*—Average crop.

*Potatoes.*—2 to 3 tons more than last year; yield from 8 to 10 tons; quality fine. Disease on earlier varieties, such as Sutton's Early Regents, but little in later varieties. No new varieties planted.

*Turnips.*—Swedes from 25 to 30 tons; brairded well; no resowing. Yellows, 18 to 20 tons.

No injury from insects. No injury from weeds.

*Live Stock.*—Pastures fully an average; quality better than last year. Stock throve very well; free from disease. *Clip of wool*—Average; quality good.

Lanarkshire (Lower Ward). *Wheat.*—40 bushels, not so good as last year; seed sown, 3½ bushels.

*Barley.*—Almost none grown.

*Oats.*—48 bushels, about same as last year; seed sown, 4 bushels.

*Harvest* began 28th August, about the usual time, but two weeks later than last year.

*Hay.*—1¾ ton; not so good as last year in quality. *Meadow-hay*—More productive this year.

*Potatoes.*—About two-thirds of last year's crop, about 6 tons; a good deal of disease, one-third in early kinds in August. Imperators, with a good result.

*Turnips.*—15 tons, about two-thirds of last year; brairded well, and once sown.

No injury by insects. No injury by weeds, but by wet weather.

*Live Stock.*—Pastures about one-third of last year. Stock throve fairly well—not so good as last year—and were free from disease. *Clip of wool*—Almost no sheep.

Renfrewshire (Middle Ward). *Wheat.*—From 40 to 50 bushels; quality fair; straw about average; seed sown, about 4 bushels.

*Barley.*—Scarcely any grown.

*Oats.*—From 36 to 54 bushels; quality fair; straw about average; seed sown, about 6 bushels.

*Harvest* began about eight days later than last season.

*Hay.*—About 35 cwt. ryegrass hay. Timothy, about 2 tons; mostly secured in good condition. Second cut after ryegrass almost *nil.* *Meadow-hay*—under last year.

*Potatoes.*—In our immediate neighbourhood, with a few exceptions, quantity was under last year. From 5 to 6 tons would be about the average. In some cases disease injured one-third of the crop.

*Turnips.*—From 15 to 18 tons would be about the average; brairded fairly well, but want of sunshine kept them from being the full crop of last season.

No injury by insects or weeds.

*Live Stock.*—Pastures not equal to last year. Stock throve fairly well. Cattle and sheep exceptionally free from disease. *Clip of wool*—About average.

Renfrewshire (Upper Ward). *Wheat.*—Not much grown; quality of grain and straw good; the weather was favourable; quantity 36 bushels; seed sown, 3 bushels.

*Barley.*—None sown in district.

*Oats.*—Good crop, from 30 to 36 bushels; good bulk of straw. A good deal of crop was spoiled with heating in stacks, owing to close sultry weather after harvest.

*Harvest* started about the end of August.

*Hay.*—Rather below average of two previous years, about 30 cwt., quality good. *Meadow-hay*—Average crop; very much spoiled with wet weather.

*Potatoes.*—A very small crop, but free from disease; from 4 to 6 tons. No new varieties. Maincrops mostly planted, as they are free from disease.

*Turnips.*—Brairded well, but owing to cold spring crop was deficient; about 16 tons.

No injury by insects. Not much troubled with weeds.

*Live Stock.*—Good pasture. Cattle throve well, and very free from disease. *Clip of wool*—Average.

Renfrewshire (Lower Ward). No *wheat* and no *barley* grown. The *oat* crop was not so good as that of the previous year. It was uneven and much deteriorated by unequal ripeness, and the unripe mixture of grain and straw detracted from the value of the crop; it, with the other causes after referred to, increased the difficulty of harvesting. The weather for the harvest was exceptionally dry, and there was little if any rainfall during that period, the amount of rain in September only registering 0.20, the 25th of that month registering 0.09, and there were twenty-five days dry; but the absence of wind proved a serious drawback in securing good condition, and stacks being put together too hurriedly, disastrous results arose from heating, and many had to be

thrown out to arrest damage, which in too many cases had occurred and past remedy. The yield of grain and straw did not differ much from the crop of 1893, but the quality suffered from the causes above referred to.

*Harvest* began about the usual time, but somewhat later than in 1893.

*Ryegrass-hay* suffered very much from the exceptional frost at the middle of May checking vegetation, which was remarkably early, the result being that the crop was light and did not on an average exceed 1 to 1½ ton. The season was favourable for its being well secured, and the quality was fairly good. *Meadow-hay*, was above average, and of excellent quality.

The *potato* crop, while not as bulky as last year, was very good, and averaged from 6 to 7 tons. A little disease appeared in the early kinds, but generally speaking it showed itself in a very small degree, and the crop escaped in this respect to a much greater extent than has been the case for many years.

The *turnip* crop did not suffer from the fly, and few, if any, second sowings were necessary; the dry weather, however, in the autumn retarded the development of the roots, and those that were early stored were very deficient in size and weight. The early winter, which was remarkably mild, was exceptionally favourable for the crop being allowed to remain in the ground, and those who ran the risk of frost found that considerable increase in the crop manifested itself; and as there was no frost to speak of before Christmas, a much better outcome of the crop was experienced than was at one time anticipated. The weight per acre, however, was considerably below last year, and would not average more than 18 tons. Finger-and-toe showed itself more this year than usual. Swedes were a good crop, and cabbages, of which a good many are planted in this district, came away better and earlier than last year, but failed to fill up in the heart.

Insects were not observable to any undue extent, damage by them being certainly less than is generally the case.

*Live Stock.*—Pastures, like hay, suffered from the severe frosts in May. They were never known to be earlier or to give a better promise of an abundance of grass, and it is beyond dispute that if the severe frost in May had not occurred, 1894 would have been one of the finest seasons the agriculturist has experienced for many years. Stock did fairly well, and hill stock had a good lambing season, ewes being in good condition. The *clip* was average, but the price of wool continues low.

The rainfall for 1894 was 65.51 against 58.08 of the previous year, and the number of dry days 151 against 154.

Argyllshire (District of Mull and Oban). *Wheat.*—None.

*Barley.*—None.

*Oats.*—Extra good crop, 30 bushels.

*Harvest* began at the usual time.

*Hay.*—Quality of ryegrass and clover extra good; quantity fully an average, say 25 cwt. *Meadow-hay*—25 per cent better than last year.

*Potatoes.*—The quantity much less than last year; the quality extra good.

*Turnips.*—Much lighter than last year; quality very good.

No injury by insects, and not more than usual by weeds.

*Live Stock.*—Pastures during the season of average growth and quality with last year. Stock throve very well, and were free from disease. *Clip of wool*—Fully up to the average.

Argyllshire (District of Lochgilphead). *Wheat.*—None grown in this district.

*Barley.*—None grown in this district.

*Oats.*—36 bushels is about an average crop; 6 bushels sown.

*Harvest* about fourteen days later than the usual time.

*Hay.*—About 30 cwt.; fully 8 cwt. less, and inferior in quality to season 1893. *Meadow-hay*—A very fair crop over all; about an average.

*Potatoes.*—Champions—About 3 tons; very small size, but free from disease; considerably below last year's crop. Earlier sorts—Good average crop, but badly affected with disease, which commenced about end of August.

*Turnips.*—About 30 tons; not so good as last year's crop; brairded well, but in some cases had to be sown a second time owing to the severe frost on the nights of the 19th, 20th, and 21st of May.

No injury by insects. Owing to wet season, weeds were very troublesome in the turnip crop.

*Live Stock.*—Pastures started well in spring, but damaged very much by frosts and drought in May; later in season came on well, and almost equal to last year's pasture. Stock throve very well. Cattle and sheep free from disease. *Clip of wool*—Good quality; about average clip.

ARGYLLSHIRE (District of Kintyre). *Wheat.*—None.

*Barley.*—Good fair crop, fully an average; would yield from 32 to 40 bushels; grain and straw both good; seed sown, from 3½ to 4 bushels.

*Oats.*—Good crop; more straw than last year, and the crop is threshing out well. On cold land, from 24 to 32 bushels; on good land, from 40 to 48 bushels. Seed sown, about 5 to 5½ bushels.

*Harvest* was about a fortnight later than last year; weather good, and a good deal of the crop got in without any rain.

*Hay.*—From 1½ to 2 tons, and the greater part got in in good condition. *Meadow-hay*—Fair; very little grown in this district; about 1½ ton.

*Early potatoes.*—A good crop where not frosted; would average about 8 tons. *Late potatoes*—A fair crop, but in some fields a good deal of disease; would average about 6 tons.

*Turnips.*—Would average about from 18 to 22 tons; quality good; no second sowing in this district.

Damaged very little by insects; grub in a few fields. Little damage by weeds unless on cold thin land.

*Live Stock.*—The pastures during the summer were good, but owing to the cold wet weather the dairy was not up to the average. Stock throve not so well as last year, owing to the cold wet weather. No disease except swine-fever. *Clip of wool*—Good, and about an average.

ARGYLLSHIRE (Islay, Jura, and Colonsay). *Wheat.*—None grown.

*Barley.*—Almost none grown.

*Oats.*—Good average crop and well secured; bulk in grain and straw scarcely up to last year; 6 bushels usually sown.

*Harvest* was about ten days later than last season, but rather earlier than the average.

*Hay.*—Ryegrass was a considerably heavier crop than last year, and was well secured; the after crop, however, was not quite so good. *Meadow-hay*—A fair average crop.

*Potatoes.*—Not more than half the quantity of last year. Some places the disease was bad, affecting about two-thirds of the crop, while other places were quite free. No entirely new varieties planted.

*Turnips.*—Brairded well, and in few cases had there to be any resowing. The crop is a very fair average, although considerably lighter than last year.

Damage not greater than usual by insects. The crops were not materially injured by weeds, unless on poor badly cultivated land.

*Live Stock.*—The pasture was of greater growth than last year, and of

very fair quality. Stock did well, and were fairly free from disease. *Clip of wool*—A fair average crop.

ARGYLLSHIRE (District of Inverary). *Wheat.*—None grown in this district.

*Barley.*—None grown in this district.

*Oats.*—A good crop; average yield about 27 bushels; straw not heavy, and crop well saved.

*Harvest* began much about the usual time.

*Hay.*—Sown grasses—ryegrass, &c.—a moderate good crop, perhaps about 25 cwt., and well saved. *Meadow-hay*—About the same as 1893, heavier in damp land and lighter in dry; well secured.

*Potatoes.*—Rather a light crop, but quality good; 5 to 6 tons.

*Turnips* turned out in the end a very good crop; were long and slow of coming, but at last filled up well and were healthy and firm.

Scarcely any damage done by insects. No damage by weeds.

*Live Stock.*—Pastures scarce, the summer being cold; but stock throve well, and were free from disease. *Clip of wool*—Not over an average.

DUMBARTONSHIRE. *Wheat.*—30 bushels wheat and about 30 cwt. straw; both quite up to 1893; 2½ to 3 bushels seed sown.

*Barley.*—Very little grown in Dumbartonshire. Reports vary from 30 bushels upward to 45. I should say 30 to 40 bushels; straw about 25 cwt.; 3½ bushels seed sown.

*Oats.*—30 to 48 bushels in varying districts; straw about 30 cwt.; quality of both excellent. About 3½ bushels seed sown.

*Harvest* began about usual time, rather later than 1893.

*Hay.*—About 25 to 35 cwt., according to district; quality good, but in some districts clover almost entirely absent. *Meadow-hay*—Rather better than 1893.

*Potatoes.*—5 to 6 tons. Some disease in August in earlier varieties, but it did not extend. One new variety, Girtons, reported as good doers, free from disease, and good quality.

*Turnips.*—Not so heavy as 1893; 14 to 18 tons; quality good; braird good; no second sowing.

No injury by insects. No injury by weeds, except some cases of "yarr" in oats after green crop.

*Live Stock.*—Pastures—Lowland districts report good all season. Highland districts report cold in May damaged the pastures. Stock throve very well, and were free from disease. *Clip of wool*—Fully average.

STIRLINGSHIRE (Western District). *Wheat.*—None grown in the district.

*Barley.*—Little grown; average yield from 30 to 35 bushels; crop well secured, and straw of good quality.

*Oats.*—A good crop; average yield about 35 bushels; well harvested, and straw of good quality.

*Harvest* about eight days before the usual time.

*Hay.*—A fair crop; average about 30 cwt.; well mixed with clover; well secured, and mostly of fine quality. *Meadow-hay*—A fair average crop, and well secured.

*Potatoes.*—A fine crop; average yield from 7 to 9 tons; fine quality, and little disease. Not aware of any entirely new varieties being planted.

*Turnips.*—A good crop; yield about 25 tons, of fine quality; brairded well, and no second sowing required.

No injury by insects or weeds.

*Live Stock.*—Pastures of fair average growth. Stock throve well, and were free from disease. *Wool* of good quality, and rather above the average quantity.

STIRLINGSHIRE (Eastern District). *Wheat.*—40 bushels; quality of wheat not so good, as straw was much lodged; fair quality; seed, 3 bushels.

*Barley.*—32 bushels; quantity and quality good, except where put in too soon; a good deal heated in some later districts; 3¼ bushels seed.

*Oats.*—28 bushels; not so bulky as last; better in early, and not so well ripened in later districts this year; 4 bushels seed.

*Harvest* about usual, if anything later.

*Hay.*—First crop good—40 cwt. in Carse; 30 cwt. Dryfield. Second crop good and well secured; want of clover. *Meadow-hay*—A small crop, not very well secured.

*Potatoes.*—7 to 9 tons; improved much at end of season; not so much disease.

*Turnips.*—Swedes, 18 tons; yellows, 12 tons. Swedes better, yellows not so good; no second sowing.

No damage except by birds, which are very destructive to grain before harvest. No damage by weeds.

*Live Stock.*—Pastures, early part not much growth, but did well after, and stock throve well. No disease. A good *clip*, but not up to last year.

CLACKMANNANSHIRE. *Wheat.*—40 bushels; seed, 3 bushels; quantity of grain and straw above an average, and of good quality.

*Barley.*—30 bushels; seed, 3 bushels; grain and straw rather below average, and of fair quality.

*Oats.*—38 bushels; seed, 5 bushels; grain under average, straw above it; both of fair quality.

*Harvest* began about a week later than the usual time.

*Hay.*—About 2 tons, at least 12 cwt. above last year. *Meadow-hay*—Not much grown in county.

*Potatoes.*—About 6 tons; part disease in Regents, free in other varieties. No new varieties.

*Turnips.*—About 18 tons; brairded well; very little sowing second time.

No damage by insects. No more than usual.

*Live Stock.*—Pastures above average growth; no more than average quality. Stock throve fairly well. Cattle and sheep free from disease. *Clip of wool*—About an average.

FIFESHIRE (Eastern District). *Wheat.*—36 bushels; straw, 1½ ton; quality of grain better than last year, straw much the same; 3 bushels seed.

*Barley.*—30 bushels; straw, 1¼ ton; quality of grain under last year, straw much the same as last; seed, 3 bushels.

*Oats.*—40 bushels; straw, 1½ ton; quality of grain and straw better than last year; seed, 4 bushels.

*Harvest* began at usual time.

*Hay.*—2 tons; crop better than last year; quality not so good. *Meadow-hay*—1½ ton. Very little grown in district.

*Potatoes.*—4 tons; crop less than last year; very little disease, except in Regents, but few of these grown in district—Bruce and Maincrops chiefly grown. Markinch being famed for the cultivation of new varieties, has a number of different kinds raised from seed, but none of them as yet have distinguished themselves.

*Turnips.*—Yellows, 12 tons; swedes, 14 tons. Crop not so large as last year; quality good; brairded well; almost no resowing.

No damage by insects or weeds.

*Live Stock.*—Pastures were of usual growth and quality. Stock throve well, and were free from disease. *Clip of wool*—Quality good; about an average.

Fifeshire (Middle District). *Wheat.*—The yield of this grain would be nearly 32 bushels, and there would be from 1¼ to 1½ ton of straw ; so that this crop was very much better both in grain and straw than that of 1893. The quality also of grain was as good as that of the former year. The quantity of seed generally sown is about 3¼ bushels.

*Barley.*—This crop was a very bulky one ; on well-farmed land, or on land in high condition, it was too bulky ; and in most instances the crop was laid too early, so that the grain was not fully matured, and the colour was rather dark. There were comparatively few samples of really plump, fine-coloured barley. The yield would be about 36 bushels ; straw, 22 to 24 cwt. ; weight per bushel, 54 lb. ; quantity of seed, about 3 bushels.

*Oats.*—All over, this crop was a magnificent one—the crop of the season, in fact. The return of grain would be 48 bushels of good heavy oats, weighing on an average fully 42 lb. per bushel ; weight of straw, 25 cwt. On some of the later soils this crop was considerably damaged by rain, and even on early farms considerable damage was done by heating, the crop having been secured before the sap was thoroughly out of the straw. Quantity of seed sown, about 4 bushels.

*Harvest.*—Cutting was begun about the 1st of September, and was pretty general by the beginning of the second week of that month. This harvest may be said to have been a week later than an average one. There was little or no rain during harvest ; but there was very little drought, so that there was a very considerable number of heated stacks, especially of oats, and a corresponding number of brown discoloured samples.

*Hay.*—A very large crop, mostly well got, of good strong hay well mixed with clover. This crop would be nearly double the weight of the crop of 1893—from 2¼ to 2½ tons. *Meadow-hay*—Much more productive, but very little of it made in this district.

*Potatoes.*—This crop would be a very light one, considerably less than that of the preceding year. The dry weather during the month of September checked its growth, and matured the tubers much too rapidly. There were a very large number of small undersized potatoes. The crop will not turn out above 3 tons of dressed tubers and 1 ton of small. Regents and some other early sorts considerably diseased. No new varieties.

*Turnips.*—This crop was not so heavy as that of 1893, which may be styled a record one. The seed brairded well, came quickly to the hoes, and grew well until about the middle of August, when the dry weather set in and checked its growth. During the last two weeks of September and the first three weeks of October the crop, especially on hard soils, had a most miserable appearance ; but the mild genial weather of late autumn and early winter has made it an average one. Yellows, 12 tons ; swedes, 16 tons.

No damage done by insects. The growthy forcing weather of early summer rushed all grain crops quickly up, and so smothered all sorts of weeds except thistles and docks ; but almost everywhere thistles were much better seen than I ever remember.

*Live Stock.*—A very great growth of pasture all through the season, much more abundant than the pastures of the dry summer of 1893. Stock throve very well indeed, and were free from disease. *Clip of wool*—Good ; average.

Fifeshire (Western District). *Wheat.*—36 bushels. The quality of grain will be as good as last year nearly, but the straw will not, much of it being green cut. 25 cwt. straw ; 3 bushels of seed sown on the best lands, and 3½ on the inferior.

*Barley.*—32 bushels ; both grain and straw much inferior to last year ; 1 ton of straw ; 3 to 3½ bushels of seed.

*Oats.*—38 bushels; grain good useful quality, but not equal to last year, nor is the straw; 25 cwt. of straw; 4 bushels sown, and on the inferior late lands even more.

*Harvest* began in this district from the 4th to the 10th September, nearly three weeks later than the fine early harvest of 1893, and ten days late of an average.

*Hay.*—A very bulky crop, very different in this respect from last year, but much of it inferior in quality; too much clover, and a deal of it withered in the making; it won't weigh to bulk—say 2 to 2½ tons. *Meadow-hay*—A big bulky crop, but, like the clover hay, much of it badly got, and not the quality of last year—say 2 tons.

*Potatoes* have not lifted nearly such a heavy crop as last year, being very small in the run, on account of the battered hard state the land got into through the summer and the lack of moisture to swell them out in the autumn; the quality is fine, however; yield, 4 to 5 tons. No disease worth mentioning except in the earliest varieties.

*Turnips.*—Not nearly such a heavy crop as last year—in fact, on all strong poor lands they are most inferior; the weight on good turnip-soils will be about 15 to 20 tons, of the poorer soils 5 to 10. Crops brairded well; little resowing; but it all along got too much rain and cold weather.

No injury by insects. Weeds were most troublesome, and difficult to drill in the turnip-break on account of the incessant wet; but nothing unusual amongst the other crops.

*Live Stock.*—Pastures were most luxuriant the whole season, and much above average; but the quality lacked nourishment. Stock throve fairly well. Cattle and sheep free from disease, thanks to the restrictions. *Clip of wool*—Fair quality, but rather under average.

PERTHSHIRE (South-West District). *Wheat.*—A good average crop of grain and straw; 36 to 40 bushels; seed, 4 bushels.

*Barley.*—A very fair crop; 37 bushels; weight, 56 to 58 lb.; seed, 3½ bushels.

*Oats.*—An average crop; 42 bushels; 42 to 46 lb.; seed, 4 to 5 bushels.

*Harvest* began about usual time; fine weather.

*Hay.*—About 1 ton 10 cwt.; quality good. *Meadow-hay*—Average crop; quality pretty good.

*Potatoes.*—Fair crop; about 10 tons; little disease.

*Turnips.*—Barely an average crop; 18 to 22 tons; brairded well, but in a few instances were sown a second time owing to frost.

Not much injured by insects. Weeds were somewhat difficult to keep down on account of the wet weather in the end of July and beginning of August.

*Live Stock.*—Pastures grazed well all the season. Stock throve well. Cattle and sheep free from disease. *Clip of wool*—Average in quantity, and quality rather under last year's price.

PERTHSHIRE (District of Coupar-Angus). *Wheat.*—The average yield of wheat in this district will be from 30 to 36 bushels this year, as against 24 to 32 bushels last year, and the quality of both grain and straw quite equal to that of the previous year; indeed, I think the wheat crop the truest and best of all the cereals this year. Quantity of seed generally sown, from 2½ to 3½ bushels.

*Barley.*—The barley crop is inferior to that of last year both as to quantity and quality of grain and straw. Average yield of grain from 36 to 40 bushels; seed generally sown, from 2 to 3 bushels.

*Oats.*—The crop of oats was above the average of last year both as to quantity and quality of grain and straw, but in many cases a considerable bulk of the crop was destroyed by being too soon carried. Average

yield of grain from 40 to 48 bushels; seed generally sown, from 3 to 5 bushels.

*Harvest* began about the usual time, but fully a fortnight later than last year.

*Hay.*—The hay crop was a very full one this year, much superior to last year's crop as to quantity, but in many cases not well secured owing to the very wet season while making, and the quality thus very materially injured; the yield averaging from 1½ to 2½ tons. No *meadow-hay* grown in this district.

*Potatoes.*—The yield of the potato crop this year will on the average be much under that of last year, being generally very small, with a considerable proportion of disease amongst the Regents and other early varieties, but comparatively little disease amongst the Bruce, Magnums, and Main-crops. Average yield this year will not exceed 5 tons.

*Turnips.*—The turnip crop is a full average one, and quite as good as last year's. Swedes would average from 20 to 25 tons, and yellows from 15 to 20 tons. The crop brairded well, and no second sowings in this district to my knowledge.

Very little damage done to crops by insects; and little damage by weeds, except where the crop was a comparative failure otherwise, when weeds grew up and made things worse.

*Live Stock.*—The pastures continued very good during the whole season, and stock throve well on them. Both cattle and sheep have been very free of diseases of any kind, but there has been a good deal of fever amongst pigs. The *clip of wool* has been quite an average one, both as to quantity and quality.

PERTHSHIRE (District of Strathearn). *Wheat.*—Very little wheat grown; crop fair; average 30 bushels; 3 bushels sown.

*Barley.*—Fair crop, 30 to 32 bushels; badly coloured and long in ripening; about 4 bushels sown.

*Oats.*—An average crop, but when tested by threshing-machine the results are disappointing—30 to 35 bushels. Green-crop land much shorter in straw, and much longer in ripening; in many cases very much laid, and long in stook.

*Harvest* began generally about second week of September, fully a fortnight later than last year.

*Hay* crop an exceptionally heavy one, 2½ to 3 tons; on account of the wet weather secured in bad condition. Well mixed as regards clover and ryegrass. *Meadow-hay*—About an average crop, rather heavier than last year.

*Potatoes.*—A much less crop than last year, 3 to 3½ tons, and except Champions, very much diseased. Disease began early, but on account of favourable weather afterwards disappeared later on.

*Turnips.*—A full average crop on well-farmed land, but in some cases a very poor crop, 15 to 25 tons; brairded well, but damaged in many cases by finger-and-toe, especially the yellow.

Not much injured by insects—damage less than usual. Weeds not to any great extent. Wild mustard prevalent in occasional fields.

*Live Stock.*—Pastures of more than average growth, and fairly good quality. Stock throve remarkably well, and on good land were easily prepared for market. Cattle and sheep perfectly free of disease. *Clip of wool*—About an average of former years, and of fairly good quality.

PERTHSHIRE (Highland District). *Wheat.*—None grown.

*Barley.*—An average crop; weak a little in straw; not quite so heavy in weight, average 52 lb.; about 28 to 30 bushels grown; 3½ bushels sown.

*Oats.*—Good in straw and grain; about 42 bushels grown; weight about 42 lb.; 5 bushels sown.

*Harvest* about ten days later than last year, and difficult to win in consequence of no wind.

*Hay.*—Good crop; about 18 cwt. grown; ryegrass and clover well mixed. *Meadow-hay*—A good crop, and well got.

*Potatoes.*—An average crop; about 4½ tons grown; early kinds a little diseased; no new varieties.

*Turnips.*—Weight about 14 tons; brairded well; not more than one sowing required; a good deal of finger-and-toe in early sowing; crop improved well towards the last fortnight.

No injury by insects. Weeds difficult to keep down on account of wet weather.

*Live Stock.*—Pastures were very good and plentiful, but not so nutritive, on account of the wet weather. Stock throve well, and were free from disease. *Clip of wool*—Good, but prices very low.

PERTHSHIRE (District of Dunkeld and Stormont). *Wheat.*—Very little grown.

*Barley.*—Heavy crop of straw; very much laid; 30 bushels; 52 lb. to 56 lb. per bushel; want of colour; 4 bushels sown.

*Oats.*—Large crop both of straw and grain; 38 to 40 bushels; weight, 42 to 44 lb.; 5 bushels sown.

*Harvest* was late; began second week of September; a fine dry harvest.

*Hay.*—The hay crop was the heaviest for some years; about 2 tons; clover strong; not well secured. Little *meadow-hay*.

*Potatoes.*—The crop was not heavy; about 5 tons; a little disease commenced second week of August, but dry weather set in and arrested disease. Sutton's Abundance tried, and did well.

*Turnips.*—A fair average; 16 to 20 tons; the crop brairded well; got too much rain during July and August, and too dry in September.

No damage done by insects. Weeds were very difficult to kill owing to wet weather.

*Live Stock.*—Pastures very good, but quality not so good. Stock throve pretty well, but too much rain. Cattle and sheep free from disease. *Clip of wool*—An average.

FORFARSHIRE. *Wheat.*—44 bushels, of good quality; straw also good quality, and above an average quantity; 4 bushels of seed if sown by hand, and 3 if drilled in.

*Barley.*—40 bushels; a good deal of it inferior in quality, as it was very much lodged, especially the latest sown, as the growth of same was so vigorous owing to the fine hot weather in June; seeding, 3 to 4 bushels; quality as a rule not so good as last year.

*Oats.*—52 bushels; of good quality, with abundance of straw; seed, 4 to 5 bushels; straw above an average.

*Harvest* began about usual time, but about a fortnight later than last year, which was early.

*Hay.*—2 tons 5 cwt.; where cut early the quality was good, but owing to a wet July the late-cut hay was a good deal damaged. The best year for clover that ever I remember. *Meadow-hay*—More productive than last year, but not much of it grown in this neighbourhood.

*Potatoes.*—6 tons. Some of the earlier kinds were rather severely smitten with disease, which commenced about the beginning of August; later sorts withstood the disease well. Not many, if any, new varieties planted.

*Turnips.*—24 tons; quality fair; finger-and-toe doing a deal of damage;

not such a heavy crop as last year; the crop came away well, with one sowing only.

No perceptible damage by insects. Damage by weeds no more than usual.

*Live Stock.*—The best year for pasture that I ever saw, for it came early, and lasted to December—one might say from March to December. Stock throve well, and were free from disease. *Clip of wool*—An average.

ABERDEENSHIRE (District of Buchan). *Wheat.*—No wheat grown in the Buchan district.

*Barley.*—The crops of barley and bere were fully as good as those of last year with regard to straw, but the yield and weight of the grain do not equal those of last year. Average yield about 36 bushels, and the weight from 49 to 54 lb. The crop was got well secured.

*Oats.*—The oat crop looked throughout the season as one that would bulk well, but the out-turn of grain has not verified the good appearance the crop had before being cut. Average yield from 36 to 44 bushels, and the weight from 40 to 44 lb.

*Hay.*—The hay crop did not prove such a heavy one as it at one time looked to be. The first cut was not secured in such good order as that cut later in the season. The mixture of ryegrass and clovers was pretty even, and the general weight about 1¾ ton. Very little *meadow-hay.*

*Potatoes.*—The potato crop was poor throughout the district, and a good deal of disease amongst them.

*Turnips.*—The turnip crop is fully an average in the Buchan district; the crop brairded very well, hence scarcely any resowing had to be resorted to. The weight would be generally for swedes about 25 tons, and yellows much about the same.

Very little injury by insects was done to the turnip crop, and consequently less than usual. Weeds were fully as plentiful as in former years.

*Live Stock.*—The pastures were abundant throughout the season. The progress made by stock on the grass was for some time not so marked, owing to the wetness of the first part of the season. Cattle and sheep have been free from disease. About an average *clip of wool,* but the price quite as low as that of last year.

ABERDEENSHIRE (District of Formartine). *Wheat.*—Not grown to any extent in this district.

*Barley.*—Barley and bere were generally a good crop; straw abundant; the quality and weight of the grain is not so heavy as last year, owing to the want of sunshine during the ripening of the crop. Barley harvest was general about the 23d of August; the weather was favourable for reaping and carrying to the stackyard. This year's yield of grain would be 40 bushels, and the weight from 52 to 54 lb.

*Oats.*—Oats were a good crop, and abundant in straw. On the coast side, where the crop was secured before the wet weather, the quality is superior to that of the later districts. When the wet commenced on 9th October it was difficult to secure. A good deal was carried to the stack-yard in damp condition, causing heating in the stack. The quality of the grain on early farms is all that could be desired; the weight 42 to 44 lb.

*Harvest* about ten days later than last year.

*Hay.*—The hay crop was the heaviest for many years, the ryegrass and clovers being abundant. A good deal of the hay crop was spoiled by the wet weather during hay-making. No *meadow-hay.*

*Potatoes.*—Potatoes were a poor crop, owing to the excess of wet or rainy weather; they did not come to maturity and were small in size; quality fair.

*Turnips.*—Turnips near the coast side are a good crop, but inland not nearly so good. The excess of rain caused a good deal of finger-and-toe in the inland districts. This crop is various—on the coast side a good crop, inland an indifferent crop. It would be difficult to give a correct estimate of this crop in this district.

No injury done by insects. Weeds were more difficult to be kept under this year amongst turnips, owing to the wet weather.

*Live Stock.*—The pastures were abundant the whole season. Cattle and sheep did well on the pastures; plenty of pasture during the whole season. Cattle and sheep have been free from disease. The *clip of wool* was fully above last year.

ABERDEENSHIRE (District of Garioch). *Wheat.*—None grown in this district.

*Barley.*—The yield of barley is on an average slightly below that of last year, and may be stated at 40 bushels, while 51 to 53 lb. was about the average weight; 4 bushels allowed for seed.

*Oats.*—The crop of oats was a very bulky one, and to all appearance there will be a considerable quantity of straw left over to next season. The yield of grain after turnips is better than last year, while that after lea is similar. 45 bushels, at 41 lb., is about an average; quantity sown, 5 to 6 bushels.

*Harvest* was commenced about three weeks later than last year, it being general in the second week of September.

*Hay.*—Hay was a much heavier crop than last year, but owing to the wet season the quality is much inferior. The weight would be about 2 tons. No *meadow-hay.*

*Potatoes.*—The yield of the potato crop is rather less than last year. Early varieties, especially the very early sorts grown in gardens, were much diseased, but those in the fields were as a rule quite healthy, but small-sized. No new varieties worth recording.

*Turnips.*—The weight of turnip crop, though better than that of most of the surrounding districts, is 3 to 4 tons less than last year; but owing to the wet season finger-and-toe was more prevalent than in previous seasons. The crop braírded well, and no second sowing was required.

There was no injury by insects or weeds.

*Live Stock.*—In the early part of the season pasture was very scarce, but later on it was abundant. Owing to the cold wet summer, stock did not make much progress. Cattle and sheep were free from disease. The quality of yield of *wool* was much the same as in former years.

ABERDEENSHIRE (District of Strathbogie). *Wheat.*—None grown.

*Barley.*—There was a larger extent devoted to barley last year than has been for many years. The crop was fairly early, and generally of average weight. When heavy it was badly laid, caused by heavy rain-showers after it had got fully into ear. The yield is remarkably disappointing, being about 8 bushels less than the estimate before harvest. The weight varies from 50 to 54 lb.

*Oats.*—Oats generally were a fairly good crop, but several fields after lea were much destroyed by the ravages of the grub-worm, and many fields after roots were checked by yarr, and consequently did not do well. The crop is not threshing well, and all over perhaps a little over four quarters may be stated as the average return.

The *harvest* was somewhat later than usual in beginning, and in nearly every case it was very protracted, and lasted from seven to nine weeks.

*Hay.*—The hay crop was rather lighter than it generally is. As a rule, it was fairly well mixed with clovers, but owing to excessive rains during the curing season great difficulty was experienced in getting the crop secured. Much of it was spoiled owing to the weather, and rendered of little feeding value, and quite useless for horses' feed.

*Potatoes.*—The potato crop was poor, and little more than half an average. There was a good deal of disease, which began to show itself about midsummer. Maincrops were the only new variety, and so far as grown, they have given complete satisfaction to the grower, being a heavy cropper and quite healthy; they are likely to be more extensively cultivated in the near future.

*Turnips.*—The turnip crop has been most unsatisfactory, generally about half an average crop. Owing to frost and fly a good deal of second sowing had to be done on many farms on which a failure of braird was never seen before. Since harvest, however, the roots have done a good deal of growing where the land was dry and other conditions favourable. Farmers are taking good care of them, so that they may be able to spin them out till the grass season begins.

*Live Stock.*—During the earlier portion of the grazing season grass was somewhat scarce, but as the season advanced, where the pastures were not overstocked, the fields afforded abundant pasturage for stock. Cattle did not do very well on the pasture, probably owing to the wet condition of the grass and the damp bed. A dry season, even although grass be a little scarce, is always the best for cattle in Strathbogie. Cattle and sheep have been exceptionally free of disease. The *wool clip* was generally above the average.

BANFFSHIRE (Lower District). *Wheat.*—None.

*Barley.*—A good crop as to bulk of straw; the quantity was about the average yield, 32 bushels, but very few samples attained the standard weight of 54 lb.; seed used, 3 to 4 bushels.

*Oats.*—Much greater yield of straw than last year; average yield of oats 40 bushels. Some very heavy samples were put in the market, as high as 46 lb. being on offer. Seed used, 5¼ bushels.

*Harvest* began about ten days earlier than usual, although it was a week later than last year, which was a very early year.

*Hay.*—Heavier crop and better quality than the previous year; average would be well on to 2 tons. *Meadow-hay* much more productive.

*Potatoes.*—Potatoes were a deficient crop in this county; the earlier varieties were a good deal diseased.

*Turnips.*—In most cases a poor crop. Suffered much from finger-and-toe and wet season. Healthy bulbs did extra well in the end of the season. Variable weights, 16 up to 36 tons. Crop in a good few cases was nipped by frost at brairding-time and had to be resown.

Not much appearance of insects. A good deal of weeds owing to wet season.

*Live Stock.*—Pastures did much better than previous year. Stock did very well. No disease in this county. *Clip of wool*—Average quality and quantity.

BANFFSHIRE AND MORAYSHIRE (Upper District). *Barley.*—3⅝ quarters barley; straw about same as last year; seed about 4 bushels.

*Oats.*—3 quarters 6 bushels; seed about from 5 to 7 bushels.

*Harvest* began about three weeks later, and was a protracted, bad, and late harvest.

*Hay.*—About 20 tons; not so good as last year; quality inferior in most instances.

*Potatoes.*—Very poor crop, and much diseased.

*Turnips.*—About 8 tons. In some fields they were a complete failure.

Very little, if any, injury by insects. Some injury by weeds, but too much wet was the primary cause.

*Live Stock.*—Pastures better than last year. Stock throve very well, and were free from disease. *Clip of wool*—About an average.

MORAYSHIRE (Lower District). *Wheat.*—Fair crop both of grain and straw; return of grain rather under last year's, 30 to 44 bushels, averaging perhaps 36 bushels. Little wheat sown now. Some was threshed in autumn, but greater part in spring. Quality fair; straw about medium bulk, but little demand for it this year, straw of other crops being plentiful everywhere; seed, 3 to 4 bushels.

*Barley.*—Far too heavy on best farms in low country. Much loss from lodging in end of July, before grain was properly filled. A fine September allowed it to be well harvested. Colour and quality fairly good, but weight low; some of it only 48 lb. per bushel, and not much above the standard of 54 lb. Great labour and ingo of quantity in dressing and screening out small grain. Marketable barley of 53 lb. and upwards not over 30 to 36 bushels. Best and heaviest barley last year on worst farms and on those well up the hillsides. Straw very bulky everywhere; seed, 3 to 4 bushels.

*Oats.*—An unusually bulky crop. Much lodging did not spoil oats so badly as barley. They filled fairly well, and gave fully an average return of grain of good quality, weighing from 42 to 45 lb. Yield would be about same as last year, 32 to 60 bushels, averaging about 48 bushels. Straw is strong and abundant, but fresh and good for stock; seed, about 4 bushels.

*Harvest* was late. Rains and mild weather in last half of July and during the whole of August kept crops growing and hindered their ripening. Harvest began with September which was bright and fine, but wanting in drying winds. No wind almost during either September or October. Yet crop in earlier districts was stacked in good condition where it was left long enough in stook. Impatient people had much heating. Weather became wet in October, and end of harvest in later localities went well into November. Good deal of damage done.

*Hay.*—Hay was a heavier crop than in 1893, much thicker, but not perhaps quite so long. Alsike clover showed itself much more than any one remembers it to have done. All clovers grew well. The earliest and latest cut hay escaped damage in making, but much injury was done by wet weather in the middle of the making season. Yield varied from 30 cwt. to 40 cwt., averaging perhaps 35 cwt. Scarcely any *meadow-hay* is grown in this part of the country.

*Potatoes.*—A very disappointing crop; in many places almost a complete failure. Disease destroyed the earlier varieties. The strongest sorts were small in size, especially where land was to any extent damp or retentive. On light dry soils Magnums, Bruces, Cups, and others of the class were healthy but small. Would not come at best to over 6 tons; in few cases would 4 tons be exceeded.

*Turnips.*—Turnip crop good where land was dry, deep, and friable. In low places, where drainage was defective or any dampness was found, the crop was literally drowned, and in many cases wholly disappeared. The plants did well in their earlier stages, but the heavy rains of the end of July and of August destroyed many of them. Best crops about 25 tons, very similar to previous year.

Insects did little injury—less than usual. The heavy grain crops killed out weeds. Potatoes and turnips, however, were very ill to clean in consequence of the rains of July and August. In land inclined to be wet it

was impossible to clean them satisfactorily. Weeds were of all kinds common to the localities.

*Live Stock.*—Pastures did exceptionally well in the beginning and the end of the season. The last half of June and first half of July were rather dry for them. They showed signs of burning up, but the rains brought by St Swithin freshened them up, and they continued rich down to November. Stock throve well all through, but no money was made on cattle except by those who sold in June. Cattle and sheep free from disease. *Clip*—fully an average, and quality good.

NAIRNSHIRE. *Wheat.*—None.

*Barley.*—2 to 4 bushels more quantity; quality 2 to 3 lb. lighter; straw a good deal more; 4 bushels sown.

*Oats.*—Quantity very little more; more straw; quality, an average; 5 to 6 bushels sown.

*Harvest* began two weeks earlier.

*Hay.*—Quantity rather more; quality somewhat spoiled with rain after cutting.

*Potatoes.*—Much less yield; a good deal of disease.

*Turnips.*—Rather more weight; brairded well.

No injury by insects or weeds.

*Live Stock.*—Pastures during the season of average growth and quality with last year. Stock throve well, and were free from disease.

INVERNESS-SHIRE (District of Inverness). *Wheat.*—There was no wheat sown in the Inverness district in 1894.

*Barley.*—The breadth of barley sown last season was similar to recent years. Before harvest the appearance of the crop looked very promising, but the absence of sunshine during the ripening stages told upon the quality and quantity, which averaged about 1 quarter less than crop of 1893, while the average weight would be from 1 to 2 lb. under the former crop. Average quantity sown, about 3½ bushels.

*Oats.*—The oat crop was a full average both as regards quantity and quality of grain and straw. On the finest soils from 40 to 50 bushels would be an average yield, while poor soils would average some 32 bushels. Quantity sown, from 3½ to 5 bushels, according to soil and condition of land.

*Harvest* was about ten days later than usual, and fully three weeks later than 1893.

*Hay.*—The average of hay grown was more than almost any former year in the district, while the quantity was an average yield; but owing to the wet weather during the harvesting of it, much inferior hay was gathered in, but there are some excellent qualities on some farms. *Meadow-hay*—There was scarcely any grown.

*Potatoes.*—The yield of the potato crop was very much under crop 1893, while the quality would be on the whole inferior. Average yield, about 4 tons. Some disease manifested itself among the early varieties before lifting. Some new varieties were introduced with varying results.

*Turnips.*—There was a very fair turnip crop on all good well-farmed land, and little disease apparent except on yellows, which showed considerable want of vigour where late sown. Average of swedes from 25 to 28 tons, yellows 18 to 22 tons. It was very apparent among yellows that disease existed through seeds being either affected or of a weakly sort, as on several farms they were much noticed and commented upon.

There was no unusual injury noticeable by insects. The usual weeds were prolific, and somewhat difficult to eradicate owing to the moist season.

*Live Stock.*—The quantity of pasture was very abundant, but the

quality was scarcely so nutritious as the former year. Stock throve fairly well, and were free from disease. *Clip of wool*—Average.

INVERNESS-SHIRE (Skye). *Wheat.*—None grown.

*Barley.*—None grown.

*Oats.*—An average crop; secured in excellent condition; 6 bushels generally sown.

*Harvest* began about the usual time.

*Hay.*—An average crop of good quality. *Meadow-hay*—More productive; secured in excellent condition.

*Potatoes.*—A small crop of medium quality; 3 to 4 tons; excessive growth of shaws very general.

*Turnips.*—18 to 20 tons, same as last year; crop throve well; no second sowing required.

No injury from insects or from weeds.

*Live Stock.*—Pastures during the season of average growth and quality with last year. Stock throve well, and were free from disease. An average *clip*, but light.

INVERNESS-SHIRE (Lochaber). *Wheat.*—None grown.

*Barley.*—Very little grown.

*Oats.*—Quantity about 25 bushels; quality good; well harvested; straw much more bulky, nearly double that of 1893; 6 bushels of seed commonly sown.

*Harvest* began about usual time, but unusually short time occupied in it owing to fine weather.

*Hay.*—About 1½ ton; quality inferior; much damaged by rain. *Meadow-hay*—Better and well saved, weather then being fine.

*Potatoes.*—Yield about 3½ tons; much diseased in lower situations; disease commenced early in July.

*Turnips.*—Crops light, about 9 tons; brairded well, and only one sowing required.

No damage by insects; oats in some places much infested with "yair."

*Live Stock.*—Pastures below average, owing to drought following removal of hay crop. Stock did not thrive quite as well as usual. Cattle and sheep free from specific disease. A full average *clip*.

ROSS-SHIRE (District of Dingwall and Munlochy). *Wheat.*—Quantity under average, say 32 bushels; quality below average; seed, 3 to 4 bushels; quantity of straw average, and also quality.

*Barley.*—Quantity and quality much below average, say 28 to 30 bushels; straw about average in quantity and quality.

*Oats.*—Quantity about average, and quality also, say 32 bushels; quantity of straw over average, quality fair.

*Harvest* began about 18th August, average time; weather was good.

*Hay.*—The quantity of hay was up to average; quality much impaired with wet weather while being secured; quantity, say 192 tons.

*Potatoes.*—Quantity much short of last year; tubers very small; early kinds affected with disease to about 40 per cent; disease commenced early.

*Turnips.*—Crop again unequal. Swedes, say 20 to 22 tons; yellows, much affected with finger-and-toe and drought in September, say 10 to 12 tons. Turnips brairded well.

No damage by insects. Not more than usual by weeds.

*Live Stock.*—Growth of pastures was very slow early in season from cold weather, then abundant after middle of June, but having a superabundance of moisture. Stock not up to usual. Cattle and sheep free from disease. *Clip of wool*—Average.

ROSS-SHIRE (District of Tain, Cromarty, and Invergordon). *Wheat.*—33 bushels; considerably below average; 3 to 4 bushels seed.

*Barley.*—32 bushels; very much below average both in quantity and quality; seed, 3 bushels.

*Oats.*—46 bushels; quite average quality, and good weight; seed, 4 bushels.

*Harvest* quite average time, about 20th August.

*Hay.*—Over average weight; not good quality; weight, 1½ to 1¾ ton. *Meadow-hay*—None grown.

*Potatoes.*—2 to 3 tons; quite a failure.

*Turnips.*—Fair average crop on good land; on inferior, three-fourths of a crop.

Not injured by insects, but by cold wet weather. Injured by weeds. Owing to wet weather could not get them horse-hoed. Much greater than usual.

*Live Stock.*—Pastures more than average growth; of bad quality. Stock did not thrive, cattle too cold. Cattle and sheep free from disease. *Clip of wool*—Barely average for quantity; quality average.

SUTHERLANDSHIRE. *Wheat.*—None grown.

*Barley.*—Under average; light weight; seed, 4 to 5 bushels.

*Oats.*—Above average, and good quality; 38 to 42 bushels; seed, from 5 to 6 bushels; quantity and quality of straw above average; crops secured in good condition.

*Harvest* ten days to a fortnight before usual time; crops secured in good order.

*Hay.*—Much above average—generally a very heavy crop; ryegrass deficient, clover abundant; ran 1½ to 2½ tons. *Meadow-hay*—Very little grown, but crop good.

*Potatoes.*—Variable crop, 4 to 6 tons; good deal of disease, which appeared in August.

*Turnips.*—Much under average; finger-and-toe bad; swedes improved a good deal by end of year; crop so variable cannot be averaged.

Very little damage by insects. Weeds abundant, and damage greater than usual, especially to turnips, where they could not be kept under.

*Live Stock.*—Pastures better than last year both in growth and quality. Stock did well, and were free from disease. *Clip of wool*—Quality and clip average.

CAITHNESS-SHIRE.—No *wheat* grown.

*Barley.*—An average crop of grain and straw; 34 bushels, weighing 52 lb.; seed, 4 bushels.

*Oats.*—Over an average both grain and straw; weight, 46 lb.; seed, 4 to 6 bushels.

*Harvest* began about the usual time, second week in September; crop secured about middle of November.

*Hay.*—A heavy crop, 2½ tons; little rye, but clover very plentiful. *Meadow-hay*—A good crop; well secured.

*Potatoes.*—A very poor crop; a touch of summer frost in August damaged halms, and no growth made thereafter by tubers; disease also present in most instances.

*Turnips.*—On some farms a good crop of healthy bulbs, 22 to 25 tons; on other places no crop at all, being entirely diseased. Where plants escaped, considerable growth was made during autumn.

No insects, except here and there grub in oats. Damage by weeds not so much as in average years.

*Live Stock.*—There was abundance of pasture all the season, and of good quality. Sheep and cattle did well all through the summer, and ewes had

an extraordinary good time during tupping season; but all now (1st February) suffering from the continued snowstorm. Cattle and sheep very healthy. *Clip of wool*—An average.

ORKNEY. *Wheat.*—None.

*Bera.*—The average yield was about 36 bushels, weighing about 48 lb.; seed, $3\frac{1}{2}$ to $4\frac{1}{2}$ bushels.

*Oats.*—Owing to the extremely calm mild weather a good deal of the crop heated in the stackyard, but otherwise the grain was of good quality, yielding about 34 bushels, and weighing about 40 lb.; straw was above an average bulk; seed, 4 to 6 bushels.

*Harvest* commenced about 1st September, being about the same time as last year, and about ten days earlier than usual.

*Hay.*—Hay was a good crop, much better than last year, and weighs about 26 cwt.

*Potatoes.*—Injured by the wet weather in July and August, and were a light crop, about 3 to 4 tons.

*Turnips.*—Brairded well, but were also injured by the excessive rain. On wet and clayey soils they are a light crop, and a good deal injured by finger-and-toe; on dry and good soils they are in some fields a very good crop. The average crop is about 10 tons.

There was little damage done by insects, and weeds were not worse than usual.

*Live Stock.*—The pastures were good all year, and remained green until nearly the New Year. Stock throve fairly well, and cattle and sheep were free from disease. The *clip of wool* was about an average.

SHETLAND (Island of Unst). No *wheat* grown in this district.

*Barley.*—A heavy crop; straw rather light, owing to drought during summer; about 80 bushels; seed sown, 4 bushels. Crop considerably better than last year.

*Oats.*—Straw and grain heavy; about 50 bushels; grain, fine quality; seed, $5\frac{1}{2}$ bushels. Both straw and grain heavier than last year.

*Harvest* began last week of August, fully three weeks before usual time, and one week before last year.

*Hay.*—Ryegrass and clover a very heavy crop, but cannot state quantity. Crop much superior to last year. *Meadow-hay*—All wet meadows very productive, and hay of excellent quality, but dry natural grass suffered from the long-continued drought.

*Potatoes.*—A very heavy crop (for Shetland), and of very fine quality; quantity, 10 tons; no new varieties planted.

*Turnips.*—Above an average, far before last year; only one sowing was required; braird strong and healthy; no disease.

Corn braird injured to considerable extent by grub (locally called "storey"); lea ground only affected. Owing to dryness of season weeds were much less troublesome than usual, and crops received very little damage.

*Live Stock.*—Pastures generally suffered from drought, but grass fairly plentiful, and of only fair quality. Stock of all kinds throve well last year. No disease in this district amongst cattle or sheep. *Clip* last year good and heavy; over an average; very few broken fleeces.

SHETLAND (District of Lerwick). *Barley.*—Both grain and straw a better yield than last year; quality excellent; about 2 bushels seed sown.

*Oats.*—Both grain and straw a better yield than last year; quality excellent; $3\frac{1}{2}$ to 4 bushels seed sown.

*Harvest* began about three weeks before the usual time.

*Hay.*—Both ryegrass and clover a heavier crop, and the quality better, than last year. *Meadow-hay*—Better crop than last year.

*Potatoes.*—The quantity was rather larger, and the quality very superior to last year; there was a slight trace of disease; the only new variety a small crop of Maincrop kidney; the yield was good, free from disease, and of excellent quality.

*Turnips.*—In weight the crop is not equal to last year, but the quality is quite as good; crop brairded well; only one sowing.

No injury by insects or weeds.

*Live Stock.*—Pastures hardly a fair average, but better than last year. Stock throve fairly well. No disease. *Clip of wool*—The quality is good, and the quantity about a fair average.

## THE METEOROLOGY OF 1894.

The following table gives a comparison of the winds, temperature, rainfall, and sunshine of 1894 as compared with the averages of previous years:—

TABLE SHOWING FOR WIND DIRECTION AND FORCE, MEAN TEMPERATURE, RAINFALL, AND SUNSHINE, THE EXCESS ABOVE, OR THE DEFECT FROM, THE AVERAGES OF PREVIOUS YEARS FOR ALL SCOTLAND.

| | Direction of Winds—Days. | | | | | | | | | Wind Force. | Rainfall. | Mean Temperature. | Sunshine—hours. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N. | N.E. | E. | S.E. | S. | S.W. | W. | N.W. | Calms. | lb. per sq. ft. | inches. | ° | |
| January . | 0 | −1 | 1 | 0 | 1 | 1 | 0 | −1 | −1 | 1.20 | 0.94 | −0.5 | − 15 |
| February | −1 | −2 | −2 | −1 | 1 | 2 | 4 | 0 | −1 | 1.39 | 4.05 | 0.2 | − 26 |
| March . | −2 | −2 | −2 | 0 | 2 | 2 | 2 | −1 | 1 | −0.45 | −0.05 | 3.0 | 39 |
| April . . | −1 | −1 | 2 | 4 | 0 | −1 | −2 | −2 | 1 | −0.21 | −0.72 | 3.0 | − 12 |
| May . . | 2 | 2 | 0 | −1 | −1 | −2 | −1 | 1 | 0 | 0.42 | 1.17 | −3.8 | − 22 |
| June . . | 0 | 1 | 1 | 0 | −1 | −1 | −1 | 0 | 1 | −0.37 | 0.01 | −1.3 | − 50 |
| July . . | 0 | 0 | 2 | 1 | 0 | −1 | 0 | −2 | 0 | −0.39 | 0.51 | 1.1 | − 27 |
| August . | 1 | 1 | −1 | −1 | −1 | 0 | 0 | 2 | −1 | 0.15 | 1.23 | −1.2 | − 47 |
| September | 4 | 2 | 2 | −1 | −2 | −4 | −2 | 0 | 1 | −0.55 | −3.14 | −1.6 | − 12 |
| October . | 1 | 2 | 2 | 0 | 0 | −3 | −3 | −1 | 2 | −0.65 | −0.71 | −1.2 | − 9 |
| November | −2 | −2 | −2 | 2 | 3 | 4 | 2 | −1 | 0 | 0.38 | −0.19 | 3.7 | − 8 |
| December | 0 | −1 | −1 | 0 | 0 | 0 | 0 | 2 | 0 | 0.64 | −0.13 | 1.8 | − 19 |
| Year . . | 2 | −1 | 0 | −1 | 2 | −3 | −1 | −3 | 3 | −0.13 | 2.96 | 0.3 | −208 |

Thus, for Scotland taken as a whole, the year 1894 was characterised by a well-marked deficiency of south, south-west, and west winds during the growing months of the year from April to October, the deficiency being twenty-six days, but during the other five months these same winds were twenty-four days above the average. The months of March, April,

November, and December were unusually warm, and on the other hand May was one of the coldest Mays on record. As regards the mean rainfall, the amount, 7.05 inches, for February was quite phenomenal, having for the last forty years been exceeded in no month, with the single exception of December 1876, when it was 7.57 inches. As compared with the averages of these months, the rainfall of February 1894 was 135 per cent, and that of December 1876, 92 per cent in excess. September was one of the very driest months since 1856, the mean rainfall being only 0.53 inch, or 86 per cent under the average. For the whole year, the rainfall was under the average in Shetland, Orkney, at coast stations in the east from the Moray Firth to the Tweed, and in the counties of Ayr, Bute and Arran, and South Argyll, but elsewhere it was above the average. The extremes were 22 per cent under the average in the north-east of Aberdeen, and about 24 per cent above it over the inland districts indicated by a line passing Wolfelee, The Glen, Polkemmet, Lednathie, Dalnaspidal, Fort Augustus, Kyleakin, Stornoway, and the Butt of Lewis. But the most striking feature of the weather of the year was the deficiency of sunshine, which, except in March, was under the average, the deficiency amounting to 208 hours.

JANUARY.—The mean temperature of the month was 36°.6, or 0°.5 under the mean, the days being the mean, but the nights one degree under it. From the 6th to the 8th of the month temperature was very low, falling at Braemar and Perth to $-4°.0$, and at the schoolhouse of Logie Coldstone to $-7°.6$, being the lowest recorded in Scotland during this cold period. On the top of Ben Nevis temperature fell on the 6th to zero, being the lowest yet observed at that elevated position.

The rainfall was 4.85 inches, being 0.94 inch above the average. It was very irregularly distributed over the country. It was under the average on the foreshores, looking northwards, of the Pentland Firth, Moray Firth, and the Firth of Forth, the deficiency being about one-fourth of the usual rainfall; and it was also deficient to nearly the same amount in Middle Galloway and parts of Ayrshire adjoining. Everywhere else the rainfall was above the average, and greatly so over the large central district lying to the north of the Forth and the Clyde. The largest excesses above their averages were, in percentages, 103 at Braemar, 90 at Aviemore, 87 at Fort Augustus, 85 at Dalnaspidal, and 61 at Inveraray. The rainfall was also large in Shetland.

The last ten days of the month were unusually stormy.

FEBRUARY.—The mean temperature was 38°.6, or 0°.2 above

the average, the days and nights being also near the average. In the north-east of Aberdeenshire and the north of a line from Elgin to the south of the Lewis, temperature was under the average, to the extent of 1°.5 on the east coast of the counties of Sutherland and Caithness. In all other districts it was above the average, amounting at coast stations in the south-west of the country to from 1° to 2°.

The rainfall was 7.05 inches, a mean monthly rainfall only once exceeded during the past forty years. The almost unbroken succession of large cyclones which swept over Scotland during the month, more particularly from the 5th to the 12th and after the 16th, were accompanied by heavy long-continued south-westerly winds and phenomenally heavy rains. It is a singular circumstance that the north-east of Aberdeenshire escaped these rains. Thus the amount for the month was under the average, in percentages—28 at Ellon, 18 at Haddo House and Peterhead, the average at New Pitsligo, and only 2 per cent above it at Kinnaird Head. Over all other districts the rainfall was above the average, and in most parts of the country enormously so. The greatest excesses above the average are, stated in percentages, the following: 333 at North Esk Reservoir, 290 at Polmaise, 264 at Grange, Bo'ness, 259 at Polkemmet, 249 at Stobo, 247 at Edinburgh, 246 at Wolfelee, 238 at Fort Augustus, 224 at Glasgow, and 220 at Inverness.

Thunder and lightning and auroras were of very frequent occurrence.

March.—The mean temperature was 42°.4, or 3°.0 above the average, the days being 5°.3 and 0°.8 in excess. This high temperature was almost wholly due to the warmer days, the result of the clear skies and strong sunshine which prevailed. This high temperature was distributed over all districts with remarkable uniformity.

The rainfall was 2.73 inches, being only 0.05 inch less than the average. Its distribution over the country was irregular. It was under the average to the south and east of a line drawn from the Crinan Canal through Rothesay, Ayr, and The Glen, and thence northwards by Leith, Dollar, Perth, Ballater, Dunrobin, and Cape Wrath; but in all other districts, above it. The deficiency was greater, from 60 to 87 per cent, in the east from the mouth of the Spey to the Tweed; and the greatest excesses, 132 per cent at Fort Augustus, 70 at Airds—and over a wide district of this part of Scotland the fall was about a half more than the average.

April.—The mean temperature was 47°.1, or 3°.0 above the average, the excess being nearly equally partitioned between

the days and the nights. The distribution of the barometric pressure was considerably higher in the north than in the south, and still more so in the east than in the west, resulting in an anomalous predominance of east and south-east winds which prevailed on 14 days, or 6 days more than the average. Hence the high temperature, which increased as the winds crossed the heated land from east to west. Thus, while at Aberdeen it was 1°.7 and at Montrose 1°.4 above the average, it was 5°.1 at Kyleakin and 4°.0 at Fort William. No storms occurred except at several western stations on the 24th and 25th.

The rainfall was 1.43 inch, or 0.72 inch under the average. Except at a few scattered stations in the counties of Fife, Haddington, Lanark, Renfrew, and Ayr, the rainfall was under the average all over the country. To the south of the Grampian range, the deficiency was generally about a third less than the average, whereas to the north of the range it varied from 50 to 90 per cent. Thunderstorms were unusually frequent—more frequent, indeed, than has been recorded on any previous April.

May.—The mean temperature was 45°.2, or 3°.8 under the average, the days being 3°.2 and the nights 4°.5. Barometric pressure was much higher in the west than in the east, in consequence of which northerly winds prevailed five days more than the average, bringing in their train a complete change of weather, and with a great lowering of the temperature in all parts of the country. This lowering of the temperature was much greater in the east than in the west, and in the south than in the north. Thus, while in Shetland it was scarcely a degree under the average, it was nearly 4°.0 at the more southern stations. No lower mean temperature has occurred in May during the past forty years.

The rainfall was 3.46 inches, or 1.17 inch above the average. Its distribution over the country was very irregular. In the counties of Perth and Dumbarton, and parts of Argyll, Inverness, the southern half of the Outer Hebrides, and in Skye, it was a little under the average. In all other parts of the country it was above it, the excess being great, as occurs when northerly winds prevail, on the south foreshores of the Firth of Forth, the Moray Firth, and the Pentland Firth. The excess was unusually great from Peterhead to Inverness, being in percentages 190 at Keith, 160 at Gordon Castle, 138 at Boyndie and Logie Coldstone, 130 at Kinnaird Head, and 110 at Inverness, Haddo House, and Fettercairn. Hence May was unwontedly wet and cold over the whole of the east and north of Scotland, but over the west the weather was much drier and considerably warmer. Thunderstorms were still of rather frequent occurrence.

JUNE.—The mean temperature was 53°.5, or 1°.3 under the average, the deficiency being nearly equal for the days and nights. Its distribution was markedly different in various parts of the country. To the west of a line drawn from Noss-head to Skerryvore, temperature was above the average, to the extent of two degrees in the north-west; but elsewhere it was under the average. The greatest deficiency was about two degrees in the lower Tweed and at eastern stations from Aberdeen to Dundee.

The rainfall was 2.50 inches, being the average. It was above the average to the east and south of a line drawn through Fettercairn, Paisley, Drumlanrig, and Pinmore, and at several places in the west of the counties of Argyll, Inverness, and Ross. Elsewhere it was under the average. The greatest excess was on the Tweed and its affluents and along the shore of the Solway, amounting in percentages to 102 at Jedburgh and 93 at Ardwell; and the greatest deficiency in Orkney, Caithness, Sutherland, and Strathspey, being 57 at Wick and 42 at Gordon Castle.

JULY.—The mean temperature was 58°.2, or 1°.1 above the average, the excess being nearly equally distributed between the days and the nights. The greatest excess of temperature occurred in Shetland and the Outer Hebrides, which was from 3°.0 to 4°.6 above the average. In truth, July 1894 was the finest summer month known to have occurred in Shetland, and the cutting of the harvest began there earlier than anywhere else in Scotland.

The rainfall was 3.64 inches, being 0.51 inch above the average. It was most unequally distributed over the districts. It was under the average over the whole of southern Scotland to the south and south-west of the Forth, and in parts of the counties of Forfar, Argyll, Inverness, Ross, the north of Orkney, and all Shetland. Elsewhere it was above the average. The greatest excess was from Kirkwall to Aberdeenshire, the excess above the average, in percentages, being to the south of the Moray Firth, 173 at Gordon Castle, 134 at Keith, 113 at Forres, and 106 at Dunrobin; in the north, 150 at Dunnet Head, 136 at Holburn Head, and 100 at South Ronaldshay; and in the west, 138 at Stornoway, and 112 at the Butt of Lewis. The greatest deficiency, about 50 per cent, was in Shetland, and it is to this dryness and unwonted high temperature that the fine early harvest of these northern islands is to be attributed. Over a considerable breadth of the southern part of Scotland only half the usual rainfall of July was recorded. A feature of this month's rainfall was the very strong contrast between the amounts in contiguous districts.

AUGUST.—The mean temperature was 55°.4, being 1°.2 under the average, the deficiency being equally distributed between the days and the nights. It was irregularly distributed over the country, being fully a degree above the average in the north and north-west, but nearly two degrees below it at the more southern stations.

The rainfall was 4.78 inches, being 1.23 inch above the average. Except to the south of a line drawn from Islay to the head of the Solway, where less than the average rainfall was collected, it was everywhere above the average. To the north of a line drawn from Wolfelee to Monach the excess at the different stations was remarkably uniform, being about one-half more than the average. Thunderstorms, accompanied with heavy rainfalls exceeding an inch in the twenty-four hours, were of frequent occurrence. Storms of wind were almost entirely absent.

SEPTEMBER.—The mean temperature was 51°.2, being 1°.6 under the average, the days being 0°.8 and the nights 2°.3. The temperature in the north is again relatively higher than in the south. Thus at North Unst it was only the third of a degree under the average, whereas in Galloway it was two degrees and a half. Barometric pressure was maintained at an unusually high point, and as it was higher at western than at eastern stations, winds from north, north-east, and east prevailed eight days more than the average, and during the month the force of the wind was less than had been recorded for many years. Under these conditions a higher temperature was maintained near the sea than in inland situations.

The rainfall was 0.53 inch, or 3.14 inches less than the average, being absolutely the smallest rainfall of any September during the past forty years. At very many places the deficiency was from 90 to 98 per cent, and the smallest deficiency anywhere recorded was 38 per cent at Keith. Heavy dews were frequent, which, while of much benefit to pastures, delayed, in some districts seriously, the ingathering of the crops.

OCTOBER.—The mean temperature was 45°.2, or 1°.2 under the average, being almost wholly due to the greater cold of the nights, which were 2°.3 under the average. The extreme south of Argyll and the south of the Outer Hebrides had a temperature from half a degree to a degree above the average, but in all other parts it was under the average, the greatest deficiency being fully two degrees in inland districts south of the Grampians. Barometric pressure was higher in the north than in the south, and from the greater prevalence of northerly and easterly winds which resulted, low temperatures ruled.

The rainfall was 3.34 inches, or 0.71 inch less than the aver-

age. Except in two well-marked districts, it was everywhere under the average, the greatest deficiency, from 60 to 80 per cent, occurring in the counties of Ross, Inverness, Argyll, and the Hebrides. On the other hand, the rainfall was above the average in Wigtownshire and immediately adjoining parts of Ayr and Kirkcudbright, the excess being from a fourth to three-fourths the average. It was also in excess at eastern stations from the coast to about thirty miles inland from the Grampians to the Cheviots, the excess being from a fourth to a half. Storms were of frequent occurrence from the 23d to the end of the month.

NOVEMBER.—The mean temperature was 44°.3, or 3°.7 above the average, the excess being equally partitioned between the days and the nights. Barometric pressure was rather low, but it was relatively much lower in the west than in the east, and in the north than in the south. The inevitable result was an extraordinary predominance of south-westerly winds, winds from south, south-west, and west prevailing twenty-two days, or nine days more than the average. In no November during the past forty years did these winds acquire so great a predominance. Owing to their persistence and general force, temperature was very equably distributed over all districts of the country, except that in inland districts it was a little higher than near the coasts.

The rainfall was 3.63 inches, or 5 per cent under the average. Again the distribution of the rainfall was very unequal. In Mid-Galloway it was above the average; as also over a wide district marked by a line passing from the Crinan Canal round by Crieff, Fort Augustus, and Stornoway. In other words, the rainfall was large over districts open to winds from the Solway, and from the Atlantic in latitudes north of Ireland. In many places the excess was a half more than the average. Elsewhere it was under, in many districts greatly under, the average. The districts under a deficient rainfall included the whole of the east slope of Scotland, except the west of Perthshire, as is usual under such conditions, the southern division of the country to the north-east of Ireland and not open to the Solway, and the districts in the north lying east of Skye and the Hebrides, including Orkney and Shetland. The deficiency was greatest to the north of a line passing from Inverness to Montrose, where at many places less than a fourth of the average of the month was collected. At Forres, Gordon Castle, Boyndie, and Keith, the deficiency was 85 per cent.

DECEMBER.—The mean temperature was 39°.6, or 1°.8 above the average, the days being 2°.3 and the nights 1°.2 in excess.

The excess was greatest in inland situations in the south, and generally it was greater south of the Grampians than to the north. As barometric pressure diminished more rapidly than usual from south to north, steeper gradients were formed for strong south-westerly winds.

The rainfall was 3.84 inches, being nearly the average of the month, but somewhat irregularly distributed. Thus at places in the north-west it was a third above the average; but in the east, from Wick to the Tweed, the amounts were a third under the average. In other districts the rainfall varied but little from the average. Very heavy falls of snow occurred at such stations as Braemar and Glencarron.

The harvest of 1894, while from one to three weeks later than that of 1893, was ready for cutting about the usual time, except in Orkney, where it was ten days, and Shetland, where it was three weeks, earlier than usual, owing chiefly to the exceptionally fine weather which prevailed there in July.

*Wheat*, except in one or two districts, was a full average; but heavy rains in July and August caused a good deal of "lodging," and consequent depreciation of the quality of the grain. *Barley* exceeded the average in only two or three districts, was under it in a greater number, but attained the average in about half the number of the districts. This crop also suffered much from the rains, and in later districts also from the moist sultry weather. In most districts, particularly to the north of the Forth and Clyde, *oats* were a full average; and in the more northern districts, including Orkney and Shetland, the crop was a very fine one, and in Shetland unprecedentedly early.

*Potatoes.*—The frosts of May 19, 20, and 21 very seriously injured the crop in all early-growing districts, and frost in August also did no little damage in the north. The crop generally was rather under the average, especially to the south of the Moray Firth, where disease was bad, and also in southern and western districts. The earlier varieties and Regents suffered a little from disease, but otherwise the crop may be described as nearly free from disease.

In the south-west, and in Banffshire and the west of Aberdeenshire, *turnips* were a poor crop; but elsewhere they were either a good average, or in a few districts a full average.

# AGRICULTURAL STATISTICS OF SCOTLAND.—Returned upon 4th June 1894.—(*Compiled from the Government Returns.*)

**Table No. 1.—Acreage under each kind of Crop, Bare Fallow, and Grass, in each County of Scotland.**

| Counties. | Total Acreage under Crops, Bare Fallow, and Grass. | Corn Crops. | | | | | | | Green Crops. | | | | | | | Clover, Sainfoin, and Grasses under Rotation. | Permanent Pasture (exclusive of Mountain Land). | Flax. | Small Fruit. | Bare Fallow or Uncropped Arable Land. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Wheat. | Barley or Bere. | Oats. | Rye. | Beans. | Peas. | Total. | Potatoes. | Turnips. | Mangels. | Cabbage, Kohl-rabi, and Rape. | Vetches or Tares. | Other Green Crops. | Total. | | | | | |
| | Acres. | Acres. | Acres. | Acres. | Acres. | Acres. | Acres | Acres. | Acres. | Acres. | Acres. | Acres. | Acres. | Acres | Acres. | Acres. | Acres. | Acres. | Acres | Acres. |
| 1. Aberdeen | 629,447 | 2 | 19,952 | 196,783 | 809 | 495 | 883 | 217,874 | 7,202 | 91,555 | 5 | 94 | 2,485 | 208 | 101,544 | 278,949 | 35,578 | 1 | 321 | 180 |
| 2. Argyle | 134,676 | 1 | 1,748 | 18,211 | 420 | 125 | 1 | 20,506 | 4,861 | 5,680 | 23 | 126 | 32 | 41 | 10,713 | 26,973 | 75,918 | .. | 24 | 542 |
| 3. Ayr | 322,369 | 1,164 | 1,105 | 49,284 | 165 | 452 | 4 | 52,174 | 8,370 | 7,555 | 483 | 698 | 43 | 321 | 17,470 | 99,350 | 153,105 | .. | 139 | 181 |
| 4. Banff | 160,171 | 12 | 7,713 | 50,626 | 83 | 104 | 58 | 58,596 | 1,976 | 22,491 | .. | 2 | 991 | 22 | 25,482 | 65,229 | 10,817 | 3 | 15 | 29 |
| 5. Berwick | 192,268 | 1,715 | 20,524 | 35,060 | 61 | 973 | 102 | 58,405 | 2,180 | 28,058 | 92 | 495 | 868 | 31 | 31,724 | 60,111 | 41,965 | .. | 21 | 42 |
| 6. Bute | 25,551 | .. | 126 | 5,141 | 109 | 47 | 6 | 5,429 | 979 | 1,551 | 6 | 28 | 7 | 18 | 2,589 | 9,281 | 8,227 | .. | 53 | 22 |
| 7. Caithness | 110,023 | 1 | 951 | 34,880 | 35 | 8 | 10 | 35,891 | 1,758 | 14,008 | .. | 88 | 488 | .. | 16,337 | 32,456 | 25,808 | .. | 5 | 26 |
| 8. Clackmannan | 15,700 | 241 | 406 | 3,481 | 32 | 513 | .. | 4,763 | 844 | 806 | 3 | 81 | 25 | 5 | 1,264 | 8,485 | 5,934 | .. | 12 | 242 |
| 9. Dumbarton | 50,707 | 797 | 198 | 7,602 | 24 | 153 | 5 | 8,774 | 2,149 | 1,535 | 20 | 207 | 63 | 23 | 3,997 | 14,760 | 28,024 | .. | 57 | 95 |
| 10. Dumfries | 259,785 | 40 | 502 | 47,563 | 59 | 32 | 2 | 48,197 | 3,723 | 20,515 | 61 | 630 | 64 | 47 | 25,040 | 83,055 | 103,271 | .. | 84 | 188 |
| 11. Edinburgh | 188,246 | 3,360 | 5,120 | 25,800 | 24 | 266 | 92 | 34,682 | 4,621 | 12,281 | 31 | 673 | 416 | 414 | 18,436 | 34,655 | 50,129 | .. | 279 | 65 |
| 12. Elgin | 101,592 | 960 | 13,687 | 21,828 | 887 | 40 | 21 | 37,424 | 1,701 | 15,097 | 13 | 10 | 411 | 12 | 18,144 | 38,187 | 7,794 | .. | 27 | 66 |
| 13. Fife | 256,755 | 9,152 | 23,152 | 42,024 | 1,297 | 1,279 | 10 | 76,854 | 14,527 | 26,170 | 11 | 980 | 922 | 61 | 42,080 | 63,187 | 73,711 | .. | 145 | 828 |
| 14. Forfar | 252,578 | 7,992 | 28,527 | 51,534 | 1,014 | 795 | 46 | 89,908 | 12,386 | 35,482 | 12 | 186 | 674 | 105 | 48,795 | 82,214 | 81,801 | .. | 179 | 91 |
| 15. Haddington | 112,061 | 5,492 | 15,367 | 18,389 | 44 | 551 | 56 | 39,899 | 7,269 | 16,776 | 33 | 376 | 229 | 295 | 24,978 | 27,588 | 18,912 | .. | 415 | 259 |
| 16. Inverness | 160,858 | 8 | 6,871 | 30,865 | 637 | 2 | 31 | 38,414 | 6,829 | 10,870 | 9 | 14 | 155 | 12 | 17,889 | 31,184 | 62,921 | .. | 35 | 410 |
| 17. Kincardine | 120,959 | 410 | 10,988 | 30,934 | 65 | 574 | 33 | 42,959 | 2,536 | 18,265 | .. | 12 | 457 | 41 | 21,311 | 47,351 | 9,220 | .. | 34 | 34 |
| 18. Kinross | 36,177 | 11 | 401 | 6,591 | 35 | 19 | 4 | 7,061 | 574 | 2,701 | .. | 70 | 58 | 2 | 3,400 | 10,316 | 15,349 | .. | 9 | 42 |
| 19. Kirkcudbright | 190,785 | 45 | 37 | 29,521 | 23 | 68 | 2 | 29,696 | 1,521 | 13,857 | 39 | 1,281 | 81 | 29 | 16,758 | 59,368 | 84,809 | .. | 24 | 20 |
| 20. Lanark | 256,903 | 1,734 | 333 | 40,810 | 43 | 776 | 23 | 43,719 | 4,110 | 9,604 | 18 | 1,536 | 436 | 248 | 15,952 | 101,927 | 93,048 | .. | 1,909 | 848 |
| 21. Linlithgow | 58,948 | 1,029 | 3,370 | 10,876 | 47 | 460 | 7 | 15,809 | 1,609 | 4,117 | 1 | 151 | 227 | 32 | 6,137 | 15,765 | 21,584 | .. | 22 | 126 |
| 22. Nairn | 25,912 | 15 | 3,164 | 5,861 | 172 | .. | 23 | 9,235 | 842 | 4,192 | .. | 1 | 39 | .. | 4,574 | 8,849 | 8,245 | .. | 8 | 6 |
| 23. Orkney | 105,358 | .. | 4,846 | 33,834 | .. | 3 | 40 | 38,725 | 2,916 | 14,812 | 1 | 48 | 812 | .. | 17,589 | 82,457 | 16,341 | .. | 1 | 240 |
| 24. Shetland | 55,484 | .. | 2,049 | 7,266 | 1 | .. | .. | 9,316 | 3,159 | 1,265 | .. | 463 | 2 | .. | 4,889 | 1,054 | 39,714 | .. | .. | 511 |
| 25. Peebles | 46,816 | 10 | 517 | 8,587 | 14 | 4 | 13 | 9,145 | 393 | 4,353 | .. | 296 | 81 | 1 | 5,124 | 17,481 | 15,001 | .. | 4 | 1 |
| 26. Perth | 336,467 | 5,626 | 15,101 | 68,492 | 716 | 2,185 | 30 | 92,150 | 18,214 | 30,293 | 15 | 257 | 453 | 46 | 44,278 | 96,905 | 101,072 | 2 | 058 | 1,407 |
| 27. Renfrew | 93,552 | 1,462 | 115 | 12,767 | 60 | 338 | 6 | 14,748 | 2,997 | 2,407 | 30 | 340 | 37 | 61 | 5,872 | 23,118 | 49,916 | 3 | 76 | 124 |
| 28. Ross & Cromarty | 137,791 | 914 | 11,113 | 32,146 | 981 | 5 | 21 | 45,180 | 3,092 | 16,780 | 12 | 9 | 576 | 4 | 25,363 | 40,130 | 26,028 | .. | 15 | 175 |
| 29. Roxburgh | 130,597 | 367 | 13,358 | 30,789 | 5 | 166 | 54 | 44,734 | 1,404 | 22,877 | 7 | 517 | 346 | 50 | 25,201 | 57,295 | 53,286 | .. | 68 | 13 |
| 30. Selkirk | 30,673 | .. | 366 | 5,228 | .. | .. | 7 | 5,601 | 197 | 2,957 | 1 | 220 | 73 | .. | 3,448 | 10,051 | 11,527 | .. | 48 | 3 |
| 31. Stirling | 118,457 | 1,319 | 3,765 | 13,955 | 47 | 3,039 | 12 | 27,637 | 3,253 | 4,521 | 10 | 183 | 309 | 63 | 8,339 | 35,231 | 45,726 | .. | 137 | 1,337 |
| 32. Sutherland | 31,787 | 2 | 1,622 | 7,777 | 184 | 23 | 3 | 9,610 | 1,697 | 3,084 | .. | 11 | 30 | .. | 4,828 | 8,286 | 9,059 | .. | 5 | 43 |
| 33. Wigtown | 153,005 | 456 | 931 | 35,318 | 60 | 236 | 3 | 36,999 | 1,530 | 16,429 | 114 | 248 | 123 | 174 | 18,618 | 66,626 | 30,527 | .. | 18 | 217 |
| Total | 4,892,183 | 44,866 | 218,057 | 1,024,228 | 7,598 | 18,757 | 1,124 | 1,309,620 | 129,859 | 483,253 | 1,050 | 9,681 | 11,459 | 2,361 | 687,668 | 1,577,669 | 1,354,477 | 9 | 4,882 | 7,868 |

TABLE No. 2.—ESTIMATED TOTAL PRODUCE OF WHEAT, BARLEY, AND OATS, ACREAGE and Estimated AVERAGE YIELD per Acre in the Year 1894, with the AVERAGE YIELDS for the Year 1893 and for the period 1885-94, and with the Estimated ORDINARY AVERAGE in each COUNTY of SCOTLAND.

| Counties. | Wheat. | | | | | | Barley, including Bere. | | | | | | Oats. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | |
| | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. |
| | Bush. | Acres. | Bush. | Bush. | Bush. | Bush. | Bush. | Acres. | Bush. | Bush. | Bush. | Bush. | Bush. | Acres. | Bush. | Bush. | Bush. | Bush. |
| Aberdeen | 54 | 2 | 27.00 | 22.00 | 30.18 | 36.92 | 691,586 | 19,952 | 34.66 | 34.94 | 33.09 | 32.41 | 7,188,018 | 196,733 | 36.54 | 35.51 | 33.90 | 33.05 |
| Argyle | .. | 1 | .. | 28.00 | 31.25 | — | 61,055 | 1,748 | 34.93 | 33.64 | 31.18 | 37.52 | 560,507 | 18,211 | 30.78 | 31.33 | 31.12 | 32 96 |
| Ayr | 44,244 | 1,104 | 38.01 | 40.81 | 37.51 | 31.89 | 43,924 | 1,105 | 39.75 | 42.07 | 38.96 | 40.84 | 2,245,346 | 49,284 | 45.56 | 48 66 | 46.08 | 46.29 |
| Banff | 340 | 12 | 28.33 | 31.78 | 30.93 | 35.77 | 262,091 | 7,718 | 34.06 | 38.48 | 34.44 | 35.43 | 1,787,195 | 50,626 | 35.30 | 33.46 | 33.33 | 32.70 |
| Berwick | 56,591 | 1,715 | 33.00 | 32.68 | 32.67 | 30.34 | 726,949 | 20,524 | 35.42 | 34.97 | 35.66 | 36.32 | 1,836,642 | 35,030 | 38 16 | 37.58 | 37.44 | 39.56 |
| Bute | .. | .. | .. | .. | 29.00 | .. | 4,954 | 126 | 39.56 | 38.48 | 37.40 | 34.11 | 175,045 | 5,141 | 34.05 | 34.34 | 35.70 | 31.12 |
| Caithness | 17 | 1 | 17.00 | .. | 18.75 | 21.14 | 38,309 | 951 | 40.35 | 36.63 | 32.68 | 29.96 | 1,336,125 | 34,380 | 38.81 | 35.09 | 32.19 | 30.73 |
| Clackmannan | 8,822 | 241 | 36.61 | 34.96 | 33.97 | 30.85 | 16,273 | 496 | 32.81 | 35.24 | 33 94 | 33.50 | 144,298 | 3,481 | 41.45 | 44.58 | 40.13 | 33.74 |
| Dunbarton | 30,115 | 797 | 37.79 | 40.52 | 37.94 | 30.72 | 8,700 | 193 | 45.08 | 44.32 | 38.45 | 33.21 | 336,058 | 7,602 | 44.28 | 46.32 | 38 38 | 35.66 |
| Dumfries | 1,688 | 49 | 34.45 | 30.58 | 34.02 | 33.56 | 16,144 | 502 | 32 16 | 32.35 | 33.57 | 36.16 | 1,540,873 | 47,553 | 32.40 | 32.51 | 33.54 | 35.76 |
| Edinburgh | 151,815 | 3,380 | 44.77 | 46.09 | 41.22 | 36.71 | 230,555 | 5,120 | 45.03 | 46.32 | 42.16 | 39.60 | 1,116,221 | 25,800 | 43.26 | 46.15 | 40.97 | 39.75 |
| Elgin or Moray | 32,777 | 960 | 34.14 | 34.88 | 32.93 | 30.09 | 450,784 | 13,687 | 32.94 | 33.67 | 32.99 | 35.48 | 790,559 | 21,828 | 36.23 | 35.28 | 33.32 | 35.09 |
| Fife | 325,299 | 9,152 | 35.54 | 33.99 | 33.61 | 30.16 | 808,421 | 23,152 | 34.92 | 33.20 | 34.49 | 34.00 | 1,548,200 | 42,024 | 36.84 | 37.33 | 36.13 | 36.87 |
| Forfar | 284,442 | 7,992 | 35.59 | 32.71 | 33.63 | 33.45 | 966,387 | 28,527 | 33.88 | 38.07 | 37.01 | 35.26 | 2,345,104 | 51,534 | 45.51 | 47.04 | 43.05 | 40.70 |
| Haddington | 217,456 | 5,492 | 39.60 | 37.84 | 37 40 | 35.16 | 644,763 | 15,367 | 41.96 | 43.22 | 41.44 | 40.64 | 882,487 | 18,389 | 47.99 | 48.18 | 44.55 | 44.44 |
| Inverness | 249 | 8 | 31.12 | 39.72 | 33.88 | 26.00 | 243,693 | 6,871 | 35.47 | 35.19 | 33.54 | 30.95 | 937,667 | 30,365 | 30.38 | 29.09 | 29.48 | 29.81 |
| Kincardine | 14,336 | 410 | 34.97 | 35.46 | 34.49 | 34.12 | 373,677 | 10,938 | 34.16 | 35 31 | 34.28 | 32.16 | 1,240,805 | 30,934 | 40.11 | 40.18 | 37.47 | 35.86 |
| Kinross | 354 | 11 | 32.18 | 30.00 | 29.48 | 28.85 | 13,275 | 401 | 33.10 | 35.21 | 35.81 | 29.82 | 213,734 | 6,591 | 32.43 | 34.45 | 34 54 | 32.18 |
| Kirkcudbright | 1,396 | 45 | 31.02 | 33.78 | 30.50 | 33.31 | 1,125 | 37 | 30.41 | 32.22 | 31.24 | 31.92 | 977,906 | 29,521 | 33.18 | 33.49 | 33.74 | 34.28 |
| Lanark | 63,413 | 1,734 | 36.57 | 40.55 | 36.87 | 35.95 | 11,548 | 333 | 34.68 | 40.87 | 36.63 | 34.21 | 1,478,770 | 40,810 | 36.24 | 40.11 | 35.49 | 35.03 |
| Linlithgow | 39,536 | 1,029 | 38.42 | 38.56 | 36.91 | 34.71 | 149,022 | 3,370 | 44 22 | 44.29 | 42.61 | 42.65 | 439,352 | 10,376 | 42.34 | 43.61 | 40.90 | 42.13 |
| Nairn | 480 | 15 | 32.00 | 33.00 | 29.92 | — | 100,126 | 3,164 | 34.49 | 36.05 | 33.49 | 34.81 | 220,618 | 5,861 | 37.64 | 37.86 | 34.39 | 35.25 |
| Orkney | .. | .. | .. | .. | 30.00 | .. | 160,228 | 4,848 | 33.05 | 32.06 | 32.37 | 36.18 | 987,052 | 33,834 | 29.17 | 28.20 | 29 09 | 34.42 |
| Peebles | 300 | 10 | 30.00 | 34.00 | 30.65 | — | 17,355 | 517 | 33.57 | 35.77 | 33.40 | 31.28 | 287,172 | 8,587 | 33.44 | 36.98 | 33.76 | 34.02 |
| Perth | 199,906 | 5,626 | 35.53 | 36.47 | 35.07 | 33 30 | 497,353 | 15,101 | 32.94 | 34.16 | 33.74 | 34.13 | 2,385,999 | 68,492 | 34.84 | 33.40 | 34.26 | 36.30 |
| Renfrew | 60,443 | 1,462 | 41.34 | 42.75 | 40.29 | 33.64 | 5,028 | 115 | 43.72 | 46.42 | 43.18 | 37.57 | 563,882 | 12,767 | 44.13 | 47.63 | 43.76 | 42.09 |
| Ross and Cromarty | 40,103 | 914 | 43.38 | 44.18 | 36.41 | 34.34 | 452,526 | 11,113 | 40.72 | 40.87 | 35.42 | 31.95 | 1,346,101 | 32,146 | 41.87 | 40.20 | 35.53 | 36.17 |
| Roxburgh | 11,023 | 367 | 30.04 | 29.13 | 33.54 | 30.77 | 457,244 | 13,353 | 34.24 | 36.33 | 35.48 | 35.51 | 1,062,787 | 30,789 | 34.52 | 36.56 | 34.75 | 37.02 |
| Selkirk | .. | .. | .. | 30.00 | 26.80 | 26.00 | 11,416 | 366 | 31.19 | 32.71 | 31.36 | 29.11 | 158,540 | 5,228 | 29.87 | 34.38 | 30.69 | 29.67 |
| Shetland | .. | .. | .. | .. | .. | .. | 65,302 | 2,049 | 31.87 | 24.18 | 21.41 | 20.47 | 241,205 | 7,266 | 33.20 | 25.66 | 17.65 | 20.29 |
| Stirling | 68,157 | 1,819 | 37.47 | 35.28 | 33.08 | 30.17 | 130,278 | 3,765 | 34.60 | 35.84 | 33.91 | 31.32 | 762,405 | 18,955 | 40.22 | 41.50 | 36.21 | 31.95 |
| Sutherland | 60 | 2 | 30.00 | 25.00 | 23.82 | — | 54,270 | 1,622 | 33.46 | 33.06 | 31.23 | 30.33 | 247,521 | 7,777 | 31.83 | 29.97 | 33.29 | 36.96 |
| Wigtown | 12,200 | 456 | 26.75 | 26.71 | 28.71 | 30.11 | 28,950 | 931 | 31 10 | 29.27 | 31.08 | 30.57 | 1,281,593 | 35,313 | 36.29 | 38.51 | 37.14 | 36.42 |
| Total | 1,665,116 | 44,866 | 37.11 | 36.58 | 35.32 | 32.85 | 7,753,001 | 218,057 | 35.55 | 36.33 | 35.26 | 34.47 | 38,160,887 | 1,024,223 | 37.26 | 37.65 | 35 60 | 35.75 |

TABLE No. 3.—ESTIMATED TOTAL PRODUCE OF BEANS, PEAS, AND POTATOES, ACREAGE and Estimated AVERAGE YIELD per Acre in the Year 1894, with the AVERAGE YIELDS for the Year 1893 and for the period 1885-94, and with the Estimated ORDINARY AVERAGE in each COUNTY of SCOTLAND.

| Counties. | Beans. | | | | | | Peas. | | | | | | Potatoes. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | |
| | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. |
| | Bush. | Acres. | Bush. | Bush. | Bush. | Bush. | Bush. | Acres. | Bush. | Bush. | Bush. | Bush. | Tons. | Acres. | Tons. | Tons. | Tons. | Tons. |
| Aberdeen | 12,679 | 495 | 25.61 | 24.80 | 24.57 | 28.26 | 9,217 | 383 | 24.07 | 23.65 | 21.25 | 23.27 | 28,928 | 7,202 | 4.02 | 6.54 | 4.95 | 5.40 |
| Argyle | 2,510 | 125 | 20.08 | 20.56 | 22.76 | 35.13 | 21 | 1 | 21.00 | 18.00 | 24.80 | 37.62 | 21,229 | 4,861 | 4.37 | 5.52 | 5.30 | 5.47 |
| Ayr | 15,603 | 452 | 34.52 | 35.17 | 32.92 | 34.47 | 122 | 4 | 30.50 | 37.60 | 34.52 | 34.96 | 48,125 | 8,370 | 5.75 | 7.31 | 6.33 | 7.03 |
| Banff | 2,374 | 104 | 22.83 | 21.38 | 25.78 | 27.29 | 1,355 | 58 | 23.36 | 22.37 | 21.48 | 23.02 | 8,235 | 1,976 | 4.17 | 6.26 | 4.64 | 4.62 |
| Berwick | 34,127 | 973 | 35.07 | 31.32 | 30.44 | 33.91 | 2,413 | 102 | 23.66 | 26.25 | 23.56 | 24.75 | 12,402 | 2,180 | 5.69 | 5.95 | 5.90 | 5.92 |
| Bute | 897 | 47 | 19.09 | 20.25 | 23.48 | 30.96 | 92 | 6 | 15.33 | 16.00 | 21.55 | 27.88 | 5,326 | 979 | 5.44 | 6.97 | 6.79 | 6.41 |
| Caithness | 89 | 8 | 11.12 | 8.00 | 14.90 | — | 271 | 16 | 16.94 | 14.00 | 16.27 | — | 4,690 | 1,758 | 2.67 | 7.04 | 4.07 | 5.52 |
| Clackmannan | 13,824 | 513 | 26.95 | 28.41 | 29.07 | 26.97 | .. | .. | .. | .. | 26.44 | — | 2,653 | 344 | 7.71 | 9.37 | 6.79 | 5.48 |
| Dumbarton | 4,634 | 153 | 30.29 | 32.12 | 28.42 | 27.74 | 98 | 5 | 19.60 | 18.00 | 21.99 | 27.24 | 16,618 | 2,149 | 7.73 | 8.90 | 7.50 | 6.70 |
| Dumfries | 793 | 32 | 24.78 | 21.68 | 27.55 | 29.97 | 41 | 2 | 20.50 | 21.00 | 25.03 | 33.73 | 22,780 | 3,723 | 6.12 | 7.08 | 6.28 | 6.24 |
| Edinburgh | 9,707 | 266 | 36.49 | 34.26 | 31.74 | 35.58 | 2,422 | 92 | 26.33 | 24.63 | 23.81 | 27.51 | 29,941 | 4,621 | 6.48 | 7.76 | 6.82 | 5.89 |
| Elgin or Moray | 1,385 | 46 | 30.11 | 24.97 | 28.97 | 31.93 | 504 | 21 | 24.00 | 22.64 | 21.94 | 22.06 | 6,244 | 1,701 | 3.67 | 5.14 | 4.31 | 3.99 |
| Fife | 41,965 | 1,279 | 32.81 | 35.64 | 33.12 | 34.45 | 328 | 10 | 32.80 | 29.90 | 28.97 | 30.12 | 64,184 | 14,527 | 4.42 | 5.15 | 4.86 | 4.45 |
| Forfar | 26,514 | 795 | 33.35 | 31.65 | 32.48 | 33.85 | 1,305 | 46 | 28.37 | 27.87 | 26.61 | 25.07 | 51,267 | 12,386 | 4.14 | 5.85 | 5.39 | 5.74 |
| Haddington | 20,357 | 551 | 36.95 | 33.08 | 32.09 | 33.54 | 1,497 | 56 | 26.73 | 25.00 | 23.88 | 25.89 | 47,607 | 7,260 | 6.55 | 7.01 | 6.30 | 6.89 |
| Inverness | 34 | 2 | 17.00 | 17.20 | 23.07 | 35.50 | 861 | 31 | 27.77 | 24.27 | 26.80 | 27.81 | 18,959 | 6,329 | 2.99 | 5.65 | 4.53 | 4.90 |
| Kincardine | 18,469 | 574 | 32.18 | 32.83 | 32.06 | 31.38 | 1,059 | 38 | 27.87 | 23.50 | 24.92 | 24.00 | 10,942 | 2,536 | 4.31 | 6.93 | 5.89 | 6.46 |
| Kinross | 610 | 19 | 32.11 | 34.57 | 28.94 | 23.00 | 120 | 4 | 30.00 | 30.00 | 30.00 | .. | 3,178 | 574 | 5.54 | 6.54 | 5.82 | 5.90 |
| Kirkcudbright | 2,299 | 68 | 33.81 | 35.16 | 32.98 | 31.26 | 58 | 2 | 20.00 | 26.00 | 25.58 | 31.00 | 7,567 | 1,521 | 4.98 | 6.15 | 5.98 | 6.10 |
| Lanark | 24,716 | 776 | 31.85 | 35.17 | 32.35 | 33.60 | 666 | 23 | 28.96 | 28.44 | 26.42 | 26.00 | 27,234 | 4,110 | 6.63 | 7.89 | 6.59 | 6.52 |
| Linlithgow | 17,280 | 480 | 36.00 | 32.40 | 31.47 | 34.07 | 210 | 7 | 30.00 | 25.84 | 24.79 | — | 10,014 | 1,600 | 6.22 | 7.25 | 5.75 | 4.95 |
| Nairn | .. | .. | .. | .. | 24.67 | 28.00 | 563 | 23 | 24.48 | 23.67 | 18.90 | 12.44 | 979 | 342 | 2.86 | 4.67 | 4.48 | 5.09 |
| Orkney | — | — | — | — | 14.66 | — | — | — | — | — | 12.95 | — | 15,661 | 2,916 | 5.37 | 8.75 | 6.66 | 7.54 |
| Peebles | 112 | 4 | 28.00 | .. | 26.61 | 30.00 | 318 | 13 | 24.46 | 28.00 | 22.72 | 27.39 | 2,682 | 393 | 6.82 | 8.03 | 6.02 | 5.82 |
| Perth | 59,145 | 2,185 | 27.07 | 33.13 | 29.67 | 28.12 | 769 | 30 | 25.63 | 24.84 | 25.26 | 24.76 | 65,415 | 13,214 | 4.95 | 7.04 | 5.88 | 5.55 |
| Renfrew | 13,618 | 338 | 40.29 | 41.67 | 40.48 | 40.15 | 219 | 6 | 36.50 | 37.00 | 37.00 | 36.00 | 19,334 | 2,997 | 6.45 | 7.85 | 7.00 | 7.24 |
| Ross and Cromarty | 115 | 5 | 23.00 | 23.00 | 25.41 | 23.42 | 536 | 21 | 25.52 | 25.86 | 24.90 | 21.71 | 23,199 | 8,032 | 2.89 | 5.80 | 5.55 | 6.55 |
| Roxburgh | 5,459 | 166 | 32.89 | 31.04 | 30.24 | 33.08 | 1,456 | 54 | 26.96 | 31.49 | 26.17 | 24.96 | 7,250 | 1,404 | 5.16 | 6.82 | 5.87 | 5.78 |
| Selkirk | .. | .. | .. | .. | .. | .. | 154 | 7 | 22.00 | 32.00 | 23.08 | 24.00 | 693 | 197 | 3.52 | 4.90 | 4.54 | 5.13 |
| Shetland | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 13,642 | 3,159 | 4.32 | 3.89 | 4.25 | 6.16 |
| Stirling | 83,091 | 3,039 | 27.34 | 31.64 | 27.54 | 28.96 | 291 | 12 | 24.25 | 27.00 | 23.00 | 22.04 | 21,298 | 3,253 | 6.55 | 8.24 | 6.37 | 5.60 |
| Sutherland | 483 | 23 | 21.00 | 20.00 | 21.17 | — | 186 | 8 | 23.25 | 22.89 | 17.60 | — | 3,864 | 1,697 | 2.28 | 5.51 | 4.54 | 5.00 |
| Wigtown | 7,099 | 236 | 30.08 | 29.58 | 28.71 | 27.96 | 86 | 3 | 28.67 | 35.00 | 20.78 | 26.33 | 5,813 | 1,530 | 3.80 | 5.06 | 5.26 | 6.98 |
| Total | 419,988 | 13,754 | 30.54 | 32.48 | 30.58 | 31.87 | 27,237 | 1084 | 25.13 | 24.79 | 23.28 | 23.61 | 627,953 | 129,859 | 4.84 | 6.42 | 5.61 | 5.79 |

TABLE No. 4.—ESTIMATED TOTAL PRODUCE of TURNIPS and MANGELS, ACREAGE, Estimated AVERAGE YIELD per Acre in the Year 1894, with the AVERAGE YIELDS for the Year 1893 and for the period 1885-94, and with the Estimated ORDINARY AVERAGE in each COUNTY of SCOTLAND.

| COUNTIES. | TURNIPS. | | | | | | MANGELS. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Produce in 1894 | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894 | Acreage in 1894. | Average Yield per Acre. | | | |
| | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1885-94. | Ordinary Average |
| | Tons. | Acres. | Tons. | Tons. | Tons. | Tons. | Tons. | Acres. | Tons. | Tons. | Tons. | Tons. |
| Aberdeen | 1,158,519 | 91,555 | 12.65 | 16.40 | 14.54 | 15.13 | 50 | 5 | 11.80 | 18.00 | 10.81 | 14.00 |
| Argyle | 66,068 | 5,630 | 11.84 | 15.25 | 13.92 | 15.28 | 268 | 23 | 11.65 | 13.00 | 12.71 | 15.49 |
| Ayr | 112,746 | 7,555 | 14.92 | 23.18 | 17.36 | 16.61 | 7,454 | 483 | 15.48 | 24.33 | 16.88 | 16.82 |
| Banff | 286,931 | 22,491 | 10.54 | 16.75 | 14.32 | 14.58 | . | . | .. | 15.00 | 15.84 | .. |
| Berwick | 433,990 | 28,058 | 15.47 | 15.76 | 15.69 | 17.06 | 1,585 | 92 | 16.68 | 20.87 | 17.08 | 21.02 |
| Bute | 22,408 | 1,551 | 14.45 | 19.27 | 15.53 | 10.55 | 70 | 6 | 11.67 | 15.40 | 12.92 | 6.50 |
| Caithness | 147,038 | 14,008 | 10.50 | 20.16 | 15.68 | 15.33 | . | .. | . | 10.07 | 10.67 | . |
| Clackmannan | 9,227 | 806 | 11.45 | 13.97 | 12.27 | 14.54 | 30 | 8 | 10.00 | 13.00 | 11.96 | 10.50 |
| Dumbarton | 24,900 | 1,535 | 16.29 | 21.51 | 15.36 | 10.96 | 277 | 20 | 18.65 | 19.27 | 13.92 | 7.11 |
| Dumfries | 258,787 | 20,515 | 12.37 | 18.20 | 15.28 | 17.18 | 1,121 | 61 | 18.88 | 23.57 | 21.28 | 24.98 |
| Edinburgh | 214,427 | 12,281 | 17.46 | 21.11 | 17.10 | 14.92 | 501 | 31 | 18.10 | 18.40 | 13.70 | 16.00 |
| Elgin or Moray | 208,352 | 15,997 | 12.71 | 18.96 | 15.85 | 15.94 | 166 | 13 | 12.77 | 18.33 | 16.75 | 19.80 |
| Fife | 240,019 | 26,179 | 9.51 | 12.95 | 11.70 | 13.44 | 65 | 11 | 5.91 | 8.50 | 9.62 | 10.00 |
| Forfar | 514,897 | 35,482 | 14.51 | 17.18 | 16.16 | 17.41 | 256 | 12 | 21.33 | 20.78 | 18.45 | 17.13 |
| Haddington | 316,719 | 16,776 | 18.88 | 19.64 | 18.11 | 17.49 | 568 | 83 | 17.21 | 15.16 | 13.40 | 15.31 |
| Inverness | 110,793 | 10,870 | 10.19 | 12.06 | 12.84 | 14.82 | 110 | 9 | 12.22 | 17.00 | 20.24 | 28.50 |
| Kincardine | 232,815 | 16,265 | 12.72 | 15.97 | 13.98 | 14.87 | .. | .. | .. | .. | 16.32 | .. |
| Kinross | 34,316 | 2,701 | 12.70 | 15.11 | 12.82 | 18.54 | .. | .. | .. | .. | .. | |
| Kirkcudbright | 199,712 | 13,857 | 14.41 | 17.16 | 16.62 | 17.92 | 539 | 39 | 18.82 | 17.17 | 15.24 | 20.76 |
| Lanark | 158,949 | 9,604 | 16.55 | 21.68 | 18.25 | 17.07 | 190 | 18 | 10.56 | 17.59 | 13.08 | 13.06 |
| Linlithgow | 73,325 | 4,117 | 17.81 | 20.83 | 16.05 | 15.29 | 12 | 1 | 12.00 | 18.60 | 10.92 | 11.00 |
| Nairn | 52,553 | 4,192 | 12.54 | 14.88 | 14.08 | 14.41 | .. | .. | .. | .. | 13.38 | 18.00 |
| Orkney | 114,595 | 14,312 | 8.01 | 11.45 | 12.35 | 16.81 | 2 | 1 | 2.00 | .. | 4.08 | .. |
| Peebles | 74,100 | 4,353 | 17.02 | 19.98 | 16.02 | 16.10 | .. | .. | .. | 14.00 | 14.00 | .. |
| Perth | 412,380 | 30,298 | 13.61 | 16.16 | 14.14 | 16.78 | 158 | 15 | 10.20 | 11.85 | 11.89 | 12.00 |
| Renfrew | 39,845 | 2,407 | 16.55 | 21.38 | 16.75 | 17.67 | 469 | 30 | 15.68 | 15.12 | 15.11 | 15.07 |
| Ross and Cromarty | 168,311 | 16,730 | 10.06 | 12.17 | 12.71 | 14.01 | 149 | 12 | 12.42 | 18.29 | 22.06 | 24.18 |
| Roxburgh | 329,966 | 22,877 | 14.42 | 17.14 | 16.00 | 16.28 | 127 | 7 | 18.14 | 25.91 | 20.17 | 23.91 |
| Selkirk | 30,641 | 2,957 | 10.36 | 14.85 | 14.46 | 15.98 | 18 | 1 | 18.00 | .. | 21.67 | . |
| Shetland | 21,448 | 1,265 | 16.95 | 14.20 | 13.56 | 13.75 | .. | .. | .. | .. | .. | .. |
| Stirling | 65,701 | 4,521 | 14.53 | 19.46 | 15.10 | 14.55 | 128 | 10 | 12.80 | 16.50 | 12.22 | 11.38 |
| Sutherland | 24,856 | 3,084 | 8.06 | 11.47 | 13.35 | 17.30 | .. | .. | .. | .. | 21.33 | .. |
| Wigtown | 207,884 | 16,429 | 12.65 | 15.46 | 14.78 | 19.91 | 1,508 | 114 | 13.28 | 15.48 | 16.16 | 22.73 |
| Total | 6,316,247 | 483,258 | 13.07 | 16.64 | 14.89 | 15.94 | 15,835 | 1,050 | 15.08 | 20.95 | 16.22 | 17.78 |

TABLE No. 5.—ESTIMATED TOTAL PRODUCE OF HAY from Clover, Sainfoin, and Grasses under Rotation, also Total from Permanent Pasture, ACREAGE, Estimated AVERAGE YIELD per Acre in the Year 1894, with the AVERAGE YIELDS for the Year 1893 and the period 1886-94, and with the Estimated ORDINARY AVERAGE in each COUNTY of SCOTLAND.

| COUNTIES. | FROM CLOVER, SAINFOIN, AND GRASSES. | | | | | | FROM PERMANENT PASTURE. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Produce in 1894. | Acreage in 1894. | Average Yield per Acre. | | | | Total Produce in 1894. | Acreage in 1894.* | Average Yield per Acre. | | | |
| | | | 1894. | 1893. | Average, 1886-94. | Ordinary Average. | | | 1894. | 1893. | Average, 1886-94. | Ordinary Average. |
| | Cwt. | Acres. | Cwt. | Cwt. | Cwt. | Cwt. | Cwt. | Acres. | Cwt. | Cwt. | Cwt. | Cwt. |
| Aberdeen | 1,637,728 | 46,522 | 35.20 | 28.48 | 27.01 | 29.18 | 82,157 | 2,966 | 27.70 | 21.55 | 21.13 | 22.61 |
| Argyle | 320,561 | 10,560 | 30.36 | 29.01 | 29.69 | 30.79 | 429,015 | 14,234 | 30.14 | 23.84 | 28.61 | 26.35 |
| Ayr | 1,132,588 | 29,355 | 38.58 | 34.97 | 34.13 | 30.62 | 829,859 | 21,390 | 38.80 | 37.49 | 37.26 | 35.00 |
| Banff | 461,144 | 10,855 | 42.48 | 24.72 | 27.79 | 28.32 | 21,342 | 671 | 31.81 | 19 69 | 21.34 | 19.30 |
| Berwick | 319,541 | 9,111 | 35.07 | 27.58 | 35.18 | 39.01 | 106,400 | 3,505 | 30.36 | 24.28 | 29.86 | 35.04 |
| Bute | 64,093 | 1,987 | 32.26 | 33.00 | 35.30 | 33.41 | 20,314 | 708 | 28.69 | 28.79 | 30.44 | 34.33 |
| Caithness | 462,223 | 9,832 | 47.01 | 17.68 | 27.76 | 32.60 | 34,936 | 1,617 | 21.61 | 18.29 | 19.12 | — |
| Clackmannan | 45,784 | 1,395 | 32.82 | 32.54 | 34.81 | 30.94 | 22,894 | 743 | 30.81 | 25 00 | 29.66 | 23.84 |
| Dumbarton | 271,823 | 6,134 | 44.31 | 37.94 | 34.12 | 34.05 | 112,032 | 2,549 | 43.95 | 39.07 | 32.61 | 26.88 |
| Dumfries | 499,701 | 18,211 | 27.44 | 22.67 | 25.41 | 34.99 | 562,981 | 18,307 | 30.75 | 21.90 | 28.03 | 41.00 |
| Edinburgh | 556,191 | 11,945 | 46.56 | 41 75 | 42.22 | 37.55 | 104,237 | 3,004 | 34.70 | 33.42 | 33.09 | 34.26 |
| Elgin or Moray | 219,148 | 6,345 | 34.54 | 21.66 | 24.51 | 28.71 | 18,425 | 629 | 29.29 | 16.69 | 19.79 | 20.00 |
| Fife | 924,633 | 25,258 | 36.61 | 23.80 | 30.82 | 31.49 | 207,740 | 7,097 | 29.27 | 22.42 | 27.15 | 28.21 |
| Forfar | 738,405 | 20,295 | 36.38 | 29.84 | 30.80 | 32.78 | 66,275 | 2,651 | 25.00 | 22 33 | 26.36 | 21.48 |
| Haddington | 428,204 | 9,392 | 45.59 | 36.29 | 41.08 | 37.84 | 68,503 | 2,137 | 32 06 | 29.04 | 32.31 | 32.67 |
| Inverness | 240,161 | 12,331 | 19.48 | 16.41 | 18.41 | 21.74 | 70,649 | 5,415 | 13.05 | 10.57 | 12.14 | 13.25 |
| Kincardine | 415,888 | 12,558 | 33.12 | 22.88 | 27.86 | 27.45 | 9,044 | 445 | 20.32 | 15.13 | 13.94 | 16.09 |
| Kinross | 74,657 | 2,512 | 29.72 | 24.22 | 28.50 | 31.86 | 44,624 | 1,573 | 28.37 | 24.14 | 31.76 | 29.83 |
| Kirkcudbright | 285,623 | 9,502 | 30.06 | 25.32 | 26.49 | 28.37 | 365,910 | 12,606 | 29.03 | 23.79 | 25.75 | 28.68 |
| Lanark | 1,278,025 | 32,068 | 39.85 | 39.13 | 36.23 | 31.27 | 486,214 | 12,328 | 39.44 | 39.34 | 39.26 | 37.94 |
| Linlithgow | 281,248 | 6,462 | 43.52 | 35.97 | 37.12 | 35.07 | 68,555 | 2,286 | 29.99 | 29.45 | 31.46 | 33.77 |
| Nairn | 53,943 | 2,019 | 26.72 | 18.94 | 20.26 | 27.92 | 12,044 | 530 | 22.72 | 16.92 | 16.69 | 20.00 |
| Orkney | 202,487 | 8,780 | 23.06 | 17.80 | 22.82 | 33.88 | 8,931 | 841 | 10.62 | 4.32 | 12.62 | 23 88 |
| Peebles | 72,600 | 2,246 | 32.36 | 28.23 | 29.44 | 28.77 | 42,711 | 1,391 | 30.71 | 29.03 | 23.77 | 34.13 |
| Perth | 974,756 | 29,543 | 32.99 | 30.35 | 32.06 | 33.88 | 361,442 | 13,335 | 27.10 | 23.71 | 24.38 | 21.13 |
| Renfrew | 504,050 | 12,768 | 39.48 | 43.28 | 37.84 | 38.55 | 312,123 | 7,257 | 43.01 | 49.78 | 44.26 | 45.39 |
| Ross and Cromarty | 290,984 | 14,003 | 20.78 | 19.69 | 21.78 | 27.96 | 34,592 | 3,503 | 9.87 | 9.61 | 11.50 | 14.43 |
| Roxburgh | 303,683 | 8,289 | 36.64 | 26.64 | 34.52 | 37.74 | 173,947 | 5,598 | 31.07 | 25.20 | 31.02 | 36.49 |
| Selkirk | 30,959 | 988 | 31.34 | 25.07 | 31.88 | 37.78 | 34,535 | 1,516 | 22.78 | 19.80 | 27.40 | 30.30 |
| Shetland | 18,616 | 663 | 28.08 | 22.95 | 28.20 | 40.00 | 32,398 | 1,487 | 21.79 | 10.62 | 14 96 | 20.00 |
| Stirling | 433,101 | 12,851 | 33.70 | 32.97 | 31.04 | 29.58 | 148,452 | 4,377 | 33.92 | 28.48 | 26.32 | 19.51 |
| Sutherland | 79,024 | 3,783 | 20.89 | 17.03 | 19.29 | 19.96 | 19,762 | 1,570 | 12.59 | 9.93 | 12.12 | 9.21 |
| Wigtown | 187,910 | 4,407 | 42.64 | 37.01 | 39.55 | 33.21 | 129,060 | 4,124 | 31.29 | 24.39 | 30.42 | 32.73 |
| Total | 13,809,562 | 392,970 | 35.17 | 28.49 | 30.69 | 31.60 | 5,042,103 | 162,390 | 31.05 | 27.23 | 28.37 | 30.55 |

* Exclusive of mountain and heath land.

TABLE No. 6.—NUMBER OF HORSES, CATTLE, SHEEP, AND PIGS IN EACH COUNTY OF SCOTLAND AS RETURNED ON JUNE 4, 1894.

| COUNTIES | HORSES (including Ponies). | | | | CATTLE. | | | | SHEEP. | | | PIGS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Used solely for Agriculture, &c. | Unbroken Horses. | Mares kept solely for breeding. | Total. | Cows and Heifers in Milk or in Calf. | Other Cattle. 2 Years and above. | Other Cattle. Under 2 Years. | Total. | 1 Year Old and above. | Under 1 Year. | Total. | |
| 1. Aberdeen | 22,399 | 7,833 | 359 | 30,591 | 44,115 | 49,531 | 85,700 | 179,346 | 122,902 | 61,317 | 184,219 | 9,922 |
| 2. Argyle | 4,454 | 2,269 | 268 | 6,980 | 22,614 | 14,425 | 24,302 | 61,341 | 705,237 | 318,114 | 1,023,351 | 4,331 |
| 3. Ayr | 6,951 | 2,558 | 463 | 9,972 | 50,244 | 14,045 | 32,895 | 97,184 | 216,416 | 142,345 | 358,761 | 15,885 |
| 4. Banff | 6,285 | 2,427 | 92 | 8,804 | 12,780 | 7,088 | 23,892 | 43,760 | 40,050 | 26,690 | 66,740 | 2,341 |
| 5. Berwick | 4,245 | 1,250 | 256 | 5,751 | 3,251 | 5,739 | 8,580 | 17,570 | 158,833 | 137,715 | 296,548 | 4,001 |
| 6. Bute | 966 | 877 | 52 | 1,895 | 3,844 | 1,779 | 3,996 | 9,619 | 35,095 | 18,051 | 53,146 | 958 |
| 7. Caithness | 4,388 | 1,167 | 54 | 5,609 | 7,750 | 2,880 | 11,354 | 21,984 | 68,226 | 40,997 | 109,223 | 1,675 |
| 8. Clackmannan | 480 | 181 | 10 | 671 | 1,637 | 946 | 1,316 | 3,899 | 7,819 | 4,902 | 12,721 | 2,230 |
| 9. Dumbarton | 1,423 | 546 | 50 | 2,019 | 8,253 | 2,895 | 3,659 | 14,807 | 51,143 | 26,657 | 77,800 | 1,623 |
| 10. Dumfries | 5,559 | 2,172 | 234 | 7,965 | 19,407 | 12,516 | 25,200 | 57,123 | 320,612 | 203,692 | 524,304 | 11,908 |
| 11. Edinburgh | 3,723 | 783 | 89 | 4,594 | 11,442 | 4,013 | 4,463 | 19,918 | 106,898 | 76,218 | 183,116 | 7,057 |
| 12. Elgin | 3,782 | 1,320 | 49 | 5,151 | 6,275 | 4,206 | 11,959 | 22,440 | 36,676 | 22,547 | 59,223 | 2,428 |
| 13. Fife | 7,788 | 2,460 | 175 | 10,423 | 11,425 | 19,207 | 19,604 | 50,236 | 58,408 | 39,418 | 97,826 | 6,309 |
| 14. Forfar | 8,422 | 2,076 | 90 | 10,588 | 11,928 | 23,021 | 19,457 | 54,406 | 92,394 | 56,599 | 148,993 | 7,942 |
| 15. Haddington | 3,207 | 479 | 63 | 3,749 | 1,852 | 5,217 | 3,034 | 10,103 | 75,412 | 51,994 | 127,406 | 1,792 |
| 16. Inverness | 6,749 | 2,071 | 128 | 8,948 | 21,392 | 7,612 | 23,825 | 52,829 | 448,676 | 194,421 | 643,097 | 3,134 |
| 17. Kincardine | 4,042 | 1,249 | 73 | 5,364 | 6,997 | 7,938 | 13,549 | 28,484 | 24,172 | 14,862 | 39,034 | 2,767 |
| 18. Kinross | 761 | 350 | 15 | 1,126 | 1,220 | 1,639 | 3,918 | 6,777 | 21,407 | 14,954 | 36,361 | 544 |
| 19. Kirkcudbright | 3,920 | 2,006 | 253 | 6,179 | 16,322 | 13,218 | 18,086 | 47,626 | 251,689 | 137,037 | 388,726 | 7,908 |
| 20. Lanark | 6,116 | 2,170 | 284 | 8,570 | 39,204 | 11,350 | 20,540 | 71,094 | 146,212 | 88,707 | 234,919 | 7,788 |
| 21. Linlithgow | 1,524 | 630 | 61 | 2,215 | 4,798 | 3,853 | 3,984 | 12,635 | 16,565 | 8,654 | 25,219 | 1,872 |
| 22. Nairn | 984 | 378 | 20 | 1,382 | 1,797 | 920 | 3,837 | 6,563 | 12,423 | 4,422 | 16,845 | 706 |
| 23. Orkney | 4,775 | 1,393 | 59 | 6,227 | 9,177 | 3,619 | 13,460 | 26,256 | 16,212 | 14,652 | 30,864 | 3,498 |
| 24. Shetland | 772 | 2,831 | 2,241 | 5,844 | 7,807 | 4,873 | 6,348 | 19,028 | 61,388 | 40,025 | 101,413 | 2,877 |
| 25. Peebles | 873 | 244 | 29 | 1,146 | 2,093 | 1,594 | 3,294 | 6,981 | 110,181 | 78,962 | 189,143 | 811 |
| 26. Perth | 10,190 | 8,264 | 268 | 18,722 | 18,438 | 22,971 | 35,112 | 76,521 | 488,292 | 236,993 | 725,285 | 3,849 |
| 27. Renfrew | 2,496 | 830 | 175 | 3,501 | 16,875 | 3,034 | 5,749 | 25,658 | 22,880 | 14,881 | 36,761 | 1,499 |
| 28. Ross and Cromarty | 6,008 | 1,886 | 107 | 8,001 | 17,992 | 8,184 | 17,139 | 43,315 | 211,144 | 104,025 | 325,269 | 5,293 |
| 29. Roxburgh | 3,665 | 628 | 142 | 4,435 | 4,819 | 5,266 | 7,707 | 17,792 | 285,488 | 226,421 | 511,909 | 3,757 |
| 30. Selkirk | 580 | 93 | 18 | 691 | 1,368 | 744 | 1,504 | 3,626 | 104,149 | 79,272 | 183,421 | 540 |
| 31. Stirling | 3,452 | 1,562 | 167 | 5,181 | 11,701 | 9,156 | 11,246 | 32,103 | 79,593 | 48,088 | 127,681 | 2,520 |
| 32. Sutherland | 2,121 | 474 | 62 | 2,657 | 5,605 | 2,160 | 4,824 | 12,589 | 151,993 | 61,337 | 213,330 | 906 |
| 33. Wigtown | 4,191 | 2,283 | 276 | 6,750 | 24,180 | 7,896 | 15,757 | 47,833 | 73,814 | 45,846 | 119,660 | 11,419 |
| Total | 147,290 | 51,740 | 6,677 | 205,707 | 428,602 | 283,544 | 489,360 | 1,201,506 | 4,633,099 | 2,639,765 | 7,272,864 | 148,535 |

## Table No. 7.—Quantities and Values of the Imports of Live Cattle, Sheep, and Swine, 1892 and 1893.

| | Quantities. | | Values. | |
|---|---|---|---|---|
| | 1892. | 1893. | 1892. | 1893. |
| | No. | No. | £ | £ |
| Live cattle | 502,237 | 340,045 | 9,224,011 | 6,202,761 |
| Live sheep | 79,018 | 62,682 | 125,660 | 88,530 |
| Live pigs | 3,826 | 138 | 12,465 | 413 |
| Total | .. | .. | 9,362,135 | 6,351,704 |

## Table No. 8.—Quantities and Values of the Imports of Beef, Mutton, Pork, Bacon, Hams, Fish, Eggs, Butter, &c., 1892 and 1893.

| | Quantities. | | Values. | |
|---|---|---|---|---|
| | 1892. | 1893. | 1892. | 1893. |
| Meat— | Cwt. | Cwt. | £ | £ |
| Beef, fresh | 2,079,037 | 1,808,051 | 4,413,148 | 3,830,596 |
| Beef, salted | 275,304 | 200,514 | 388,588 | 278,097 |
| Beef, preserved otherwise | 507,991 | 385,727 | 1,349,004 | 961,731 |
| Mutton, fresh | 1,699,966 | 1,971,500 | 3,447,102 | 3,873,863 |
| Mutton, preserved | 68,412 | 83,892 | 139,202 | 154,818 |
| Pork, fresh | 132,107 | 182,091 | 310,165 | 453,544 |
| Pork, salted | 228,354 | 186,901 | 306,262 | 289,577 |
| Bacon | 3,881,378 | 3,108,887 | 7,930,121 | 8,479,816 |
| Hams | 1,233,132 | 988,411 | 2,963,712 | 2,800,253 |
| Unenumerated, salted or fresh | 150,673 | 177,509 | 344,945 | 300,912 |
| " other than by salting | 163,098 | 121,191 | 473,460 | 428,062 |
| Total | 10,500,042 | 9,304,604 | 22,065,806 | 23,043,707 |
| Fish | 2,630,617 | 2,310,838 | 2,760,000 | 2,682,751 |
| Rabbits | 107,630 | 103,823 | 303,262 | 287,737 |
| Poultry and game (see value) | .. | .. | 583,430 | 578,959 |
| Butter | 2,183,009 | 2,327,474 | 11,065,190 | 12,753,593 |
| Margarine | 1,305,370 | 1,209,970 | 3,712,884 | 3,053,344 |
| Cheese | 2,232,817 | 2,077,462 | 5,418,784 | 5,180,918 |
| Lard | 1,230,051 | 1,118,106 | 2,223,011 | 2,808,549 |
| Eggs . . . Thousands | 1,330,730 | 1,325,518 | 3,794,718 | 3,875,647 |
| Total | .. | .. | 30,750,270 | 31,808,498 |

## Table No. 9.—Quantities and Values of the Imports of Wheat and Wheat-Flour, 1892 and 1893.

| | Quantities | | Values. | |
|---|---|---|---|---|
| | 1892. | 1893. | 1892. | 1893. |
| | Cwt. | Cwt. | £ | £ |
| Wheat | 64,901,790 | 65,461,988 | 24,857,902 | 21,070,028 |
| Wheat-flour | 22,105,000 | 20,408,108 | 12,267,453 | 9,761,510 |
| Total | .. | .. | 37,125,355 | 30,831,538 |

## Table No. 10.—Quantities and Values of the Imports of Barley, Oats, Indian Corn, Rye, Meal, &c., 1892 and 1893.

| | Quantities. | | Values. | |
|---|---|---|---|---|
| | 1892. | 1893. | 1892. | 1893. |
| | Cwt. | Cwt. | £ | £ |
| Barley | 14,377,342 | 22,844,562 | 4,313,902 | 5,770,033 |
| Oats | 15,601,304 | 13,054,086 | 5,013,545 | 4,207,980 |
| Maize | 35,381,224 | 32,002,503 | 9,425,211 | 7,802,020 |
| Peas | 2,501,493 | 2,302,413 | 869,235 | 729,294 |
| Beans | 4,429,933 | 3,940,985 | 1,365,321 | 1,127,560 |
| Rye | 574,891 | 726,173 | 192,234 | 200,168 |
| Buckwheat | 131,142 | 107,290 | 40,696 | 32,599 |
| Total | .. | .. | 21,214,044 | 20,069,208 |
| Oatmeal | 414,806 | 343,487 | 226,510 | 187,208 |
| Other meals | 537,033 | 317,345 | 167,183 | 99,297 |
| Total | .. | .. | 393,693 | 286,505 |

TABLE No. 11.—AVERAGE PRICES PER HEAD OF VARIOUS KINDS OF ANIMALS, DEAD MEAT, AND PROVISIONS IMPORTED INTO THE UNITED KINGDOM IN 1892 AND 1893.

| Kind of Animals, Dead Meat, &c. | | 1892. | 1893. |
|---|---|---|---|
| Animals—Horses | each | £20 5 3 | £27 9 10 |
| " Oxen and bulls from all countries | " | 18 9 8 | 10 8 8 |
| " Sheep, including lambs, from all countries | " | 1 11 10 | 1 8 3 |
| " Pigs | " | 3 5 2 | 2 19 10 |
| Bacon—From all countries | per cwt. | 2 0 10 | 2 18 0 |
| Hams—From all countries | " | 2 7 4 | 2 18 5 |
| Beef, salted—From all countries | " | 1 8 8 | 1 7 9 |
| " fresh—From all countries | " | 2 2 5 | 2 2 4 |
| Pork, salted—From all countries | " | 1 6 10 | 1 10 11 |
| " fresh—From all countries | " | 2 6 11 | 2 10 0 |
| Butter—From all countries | " | 5 9 8 | 5 9 7 |
| Margarine | " | 2 16 11 | 2 16 2 |
| Cheese—From all countries | " | 2 8 6 | 2 9 8 |
| Potatoes—From all countries | " | 0 6 4 | 0 6 5 |
| Eggs—From all countries | per 120 | 0 6 10 | 0 7 0 |
| Lard—From all countries | per cwt. | 1 15 10 | 2 10 2 |

TABLE No. 12.—RETURN OF THE AVERAGE PRICES OF WOOL IN THE YEARS 1892 AND 1893.

| Years. | Australian. | South African. | English Fleeces. |
|---|---|---|---|
| | Per lb. s. d. | Per lb. s. d. | Per lb. s. d. s. d. |
| 1892 | 0 9 | 0 9¼ | 0 8¼ to 1 2 |
| 1893 | 0 8¾ | 0 9¼ | 0 8½ " 1 1½ |

[EDINBURGH

EDINBURGH CORN-MARKET GRAIN TABLES for WHEAT, BARLEY, OATS, and BEANS, showing the Quantity offered for Sale, the Quantity Sold, the Highest, Lowest, and Average Prices, also the Bushel-weights of the Highest and Lowest Prices of each kind of Grain for every Market-day, likewise the Results for every Month, and the final Result for the year 1894.

## WHEAT.

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | Table of Bushel-weights for Lowest Price. |
|---|---|---|---|---|---|---|---|
| 1894 Jan. | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb. lb. | lb. lb. |
| 3 | 328 | 166 | 27 0 | 26 0 | 26 2 | 63 | 63 |
| 10 | 552 | 552 | 27 3 | 25 6 | 26 5 | 63 | 62 63 |
| 17 | 906 | 703 | 28 0 | 25 3 | 26 8 | 64 | 63 |
| 24 | 599 | 360 | 26 6 | 25 0 | 26 0 | 63 64 | 62 |
| 31 | 384 | 202 | 27 0 | 24 6 | 26 1 | 64 | 62 |
| | 2,769 | 1,980 | 27 1 | 25 6 | 26 5 | | |
| Feb. 7 | 354 | 302 | 26 0 | 22 0 | 25 1 | 63 | 60½ |
| 14 | 680 | 496 | 26 6 | 21 0 | 24 9 | 64½ | 59½ |
| 21 | 914 | 692 | 25 6 | 23 0 | 24 3 | 64 | 60½ 61½ |
| 28 | 438 | 294 | 25 0 | 22 6 | 24 0 | 63½ | 61 |
| | 2,386 | 1,784 | 25 11 | 22 6 | 24 6 | | |
| March 7 | 659 | 625 | 25 6 | 22 6 | 24 0 | 64 | 62 |
| 14 | 661 | 298 | 24 6 | 23 0 | 23 8 | 63 | 63 |
| 21 | 506 | 361 | 25 0 | 21 6 | 23 8 | 64 | 62 |
| 28 | 186 | 156 | 24 0 | 20 0 | 23 2 | 63 64 | 58½ |
| | 2,012 | 1,440 | 24 10 | 22 3 | 23 9 | | |
| April 4 | 475 | 418 | 24 6 | 22 6 | 23 10 | 63¾ | 62 |
| 11 | 289 | 204 | 25 0 | 21 0 | 23 10 | 64½ | 58½ |
| 18 | 446 | 446 | 25 0 | 21 6 | 24 0 | 63 | 62 |
| 25 | 1,004 | 913 | 27 0 | 22 0 | 24 3 | 63¾ | 62 |
| | 2,214 | 1,981 | 25 11 | 21 11 | 24 3 | | |
| May 2 | 914 | 558 | 27 0 | 22 6 | 24 4 | 64 | 62½ |
| 0 | 1,024 | 791 | 24 6 | 20 6 | 23 10 | 64½ 64½ | 62 |
| 16 | 821 | 586 | 24 0 | 21 6 | 22 11 | 64 64½ | 62 |
| 23 | 1,010 | 592 | 23 6 | 18 6 | 22 0 | 63½ 63¾ | 62½ |
| 30 | 676 | 537 | 23 0 | 20 0 | 21 11 | 64½ | 62 |
| | 4,445 | 3,064 | 24 3 | 20 7 | 23 1 | | |
| June 6 | 1,109 | 1,029 | 28 0 | 21 0 | 22 2 | 63 64½ | 63 |
| 13 | 616 | 616 | 24 6 | 22 0 | 22 11 | 65 | 62½ 63½ |
| 20 | 547 | 547 | 25 0 | 23 0 | 24 1 | 65 | 63½ |
| 27 | 902 | 767 | 25 0 | 24 0 | 24 3 | 63¾ 65 | 63 |
| | 3,174 | 2,959 | 24 2 | 22 0 | 23 8 | | |
| July 4 | 452 | 265 | 24 0 | 23 0 | 23 7 | 63½ | 63 |
| 11 | 392 | 282 | 24 6 | 22 6 | 23 4 | 65 | 64 |
| 18 | 426 | 291 | 25 6 | 23 0 | 24 6 | 64½ | 63 |
| 25 | 501 | 305 | 24 6 | 23 0 | 23 8 | 64½ | 63 64 |
| | 1,771 | 1,143 | 24 7 | 22 11 | 23 9 | | |

WHEAT—*continued.*

| Date. | Quantity offered for Sale. | Quantity Sold | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | | Table of Bushel-weights for Lowest Price. | |
|---|---|---|---|---|---|---|---|---|---|
| 1894 | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb. | lb. | lb. | lb. |
| Aug. | | | | | | | | | |
| 1 | 1,050 | 711 | 25 0 | 20 6 | 23 2 | | 63½ | | 60 |
| 8 | 975 | 825 | 24 0 | 21 3 | 23 4 | 63½ | 64½ | | 62 |
| 15 | 1,104 | 904 | 24 3 | 21 0 | 23 3 | | 64½ | | 61½ |
| 22 | 973 | 673 | 25 0 | 20 6 | 22 9 | | 64 | 61 | 63 |
| 29 | 529 | 440 | 24 6 | 21 6 | 23 1 | | 63½ | | 63 |
| | 4,631 | 3,553 | 24 4 | 20 11 | 23 2 | | | | |
| Sept. | | | | | | | | | |
| 5 | 301 | 60 | 23 6 | .. | 23 6 | 63 | 64 | | .. |
| 12 | 533 | 433 | 24 3 | 18 0 | 22 9 | | 64½ | 60 | 61½ |
| 19 | 526 | 410 | 23 6 | 20 0 | 22 5 | | 65 | | 60½ |
| 26 | 315 | 155 | 23 3 | 16 6 | 20 11 | | 63½ | | 58½ |
| | 1,675 | 1,068 | 23 8 | 18 1 | 22 5 | | | | |
| Oct. | | | | | | | | | |
| 3 | 369 | 82 | 23 6 | 15 0 | 17 5 | | 63½ | 59½ | 60½ |
| 10 | 667 | 133 | 25 6 | 17 9 | 21 7 | | 64½ | | 60 |
| 17 | 302 | 190 | 25 0 | 16 3 | 21 3 | 63 | 63¾ | | 59½ |
| 24 | 720 | 166 | 24 6 | 18 0 | 22 4 | 62½ | 63½ | | 60½ |
| 31 | 763 | 300 | 25 6 | 16 0 | 20 7 | | 64 | | 60 |
| | 3,321 | 880 | 24 10 | 16 2 | 20 11 | | | | |
| Nov. | | | | | | | | | |
| 7 | 552 | 300 | 25 0 | 18 6 | 21 3 | 63½ | 64 | | 61 |
| 14 | 387 | 294 | 25 0 | 17 6 | 22 3 | | 63½ | | 58½ |
| 21 | 583 | 207 | 23 6 | 20 9 | 22 7 | | 63½ | | 61 |
| 28 | 518 | 349 | 25 6 | 19 0 | 23 1 | 63½ | 64 | | 60 |
| | 2,040 | 1,150 | 24 7 | 18 9 | 22 3 | | | | |
| Dec. | | | | | | | | | |
| 5 | 414 | 287 | 25 0 | 22 0 | 24 0 | | 63¾ | | 63 |
| 12 | 428 | 320 | 24 6 | 19 6 | 22 10 | 63 | 63½ | | 61½ |
| 19 | 287 | 201 | 24 6 | 20 6 | 23 6 | | 63 | | 58½ |
| 26 | 399 | 273 | 24 6 | 19 0 | 22 8 | | 63 | | 59½ |
| | 1,526 | 1,081 | 24 7 | 20 3 | 23 3 | | | | |
| Result for year | 31,966 | 22,087 | 24 10 | 21 11 | 23 7 | | | | |

BARLEY.

| Date. | Quantity offered for Sale. | Quantity Sold | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | | Table of Bushel-weights for Lowest Price. | |
|---|---|---|---|---|---|---|---|---|---|
| 1894 | | | | | | | | | |
| Jan. | | | | | | | | | |
| 3 | 1,560 | 1,207 | 33 6 | 24 0 | 31 6 | | 56½ | | 54 |
| 10 | 1,804 | 1,409 | 33 6 | 14 0 | 31 9 | 56 | 58 | | 46½ |
| 17 | 2,212 | 1,183 | 33 9 | 25 6 | 31 8 | | 56½ | | 54½ |
| 24 | 2,442 | 957 | 34 0 | 27 6 | 30 11 | | 56½ | | 56 |
| 31 | 1,868 | 1,103 | 32 6 | 27 0 | 30 10 | 56 | 56½ | | 56½ |
| | 9,906 | 5,859 | 33 5 | 23 1 | 31 4 | | | | |
| Feb. | | | | | | | | | |
| 7 | 1,815 | 684 | 32 0 | 23 3 | 30 0 | | 57 | | 52 |
| 14 | 1,700 | 512 | 31 6 | 27 0 | 30 4 | | 57 | | 56 |
| 21 | 1,439 | 452 | 32 6 | 27 0 | 30 0 | | 56½ | | 56 |
| 28 | 1,810 | 780 | 32 0 | 25 0 | 29 7 | 56 | 56½ | | 53½ |
| | 5,764 | 2,328 | 31 11 | 26 0 | 29 11 | | | | |

BARLEY—*continued.*

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | | Table of Bushel-weights for Lowest Price. | |
|---|---|---|---|---|---|---|---|---|---|
| 1894 March | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb. | lb. | lb. | lb. |
| 7 | 1,139 | 537 | 32 0 | 27 6 | 30 2 | 56 | 59 | | 56 |
| 14 | 1,150 | 510 | 33 0 | 26 0 | 29 7 | | 56 | | 56 |
| 21 | 959 | 482 | 33 6 | 15 0 | 20 2 | 56¼ | 56¾ | | 54 |
| 28 | 769 | 348 | 34 0 | 26 0 | 30 7 | | 56½ | | 56 |
| | 4,017 | 1,877 | 32 11 | 23 7 | 29 10 | | | | |
| April 4 | 593 | 253 | 32 6 | 28 0 | 30 7 | | 56 | 56 | 56¾ |
| 11 | 316 | 162 | 32 0 | 26 0 | 29 2 | | 56½ | | 55 |
| 18 | 226 | 86 | 30 6 | 26 6 | 27 11 | | 56 | | 56 |
| 25 | 367 | 145 | 31 6 | 28 0 | 29 1 | 55 | 56 | | 56¼ |
| | 1,502 | 646 | 31 7 | 26 7 | 29 7 | | | | |
| May 2 | 207 | 74 | 31 3 | 29 0 | 30 2 | | 56 | 55¾ | 56 |
| 9 | 249 | 75 | 30 0 | 27 6 | 29 5 | | 56¼ | | 55 |
| 16 | 112 | 47 | 30 0 | 24 9 | 26 6 | | 55 | | 54 |
| 23 | 148 | 68 | 27 0 | 25 0 | 26 4 | | 56 | | 56 |
| 30 | 27 | 12 | 27 0 | .. | 27 0 | | 55¾ | | .. |
| | 743 | 276 | 29 3 | 26 3 | 28 3 | | | | |
| June 6 | 10 | 10 | 27 0 | .. | 27 0 | | 56 | | .. |
| 13 | 36 | 36 | 27 6 | 25 3 | 26 2 | | 55¾ | | 55 |
| 20 | 46 | 25 | 29 0 | 27 0 | 28 3 | | 56 | | 55¾ |
| 27 | 44 | 23 | 26 6 | 26 0 | 26 2 | | 56 | | 56 |
| | 136 | 94 | 27 9 | 25 10 | 26 10 | | | | |
| July 4 | .. | .. | .. | .. | .. | | .. | | .. |
| 11 | .. | .. | .. | .. | .. | | .. | | .. |
| 18 | 13 | 13 | 27 0 | .. | 27 0 | | 56 | | . |
| 25 | 20 | .. | .. | .. | .. | | .. | | .. |
| | 33 | 13 | 27 0 | .. | 27 0 | | | | |
| Aug. 1 | .. | .. | .. | .. | .. | | .. | | . |
| 8 | .. | .. | .. | .. | .. | | .. | | .. |
| 15 | .. | .. | .. | .. | .. | | .. | | .. |
| 22 | .. | .. | .. | .. | .. | | .. | | .. |
| 29 | 150 | 75 | 30 0 | 28 0 | 28 8 | | 56 | | 55 |
| | 150 | 75 | 30 0 | 28 0 | 28 8 | | | | |
| Sept. 5 | 1,401 | 996 | 30 3 | 24 0 | 27 6 | | 56½ | | 55 |
| 12 | 2,696 | 1,457 | 29 6 | 21 0 | 26 11 | | 56 | 53 | 54½ |
| 19 | 2,532 | 631 | 28 6 | 19 0 | 23 10 | | 56 | | 56 |
| 26 | 2,277 | 791 | 26 0 | 19 0 | 23 2 | | 56¼ | | 53 |
| | 8,906 | 3,875 | 28 7 | 21 3 | 25 10 | | | | |
| Oct. 3 | 1,453 | 986 | 28 0 | 17 0 | 23 6 | | 56 | | 54 |
| 10 | 1,727 | 748 | 27 9 | 21 0 | 25 4 | | 56½ | 54½ | 54¾ |
| 17 | 1,367 | 894 | 28 6 | 18 0 | 23 9 | | 57 | | 51½ |
| 24 | 1,421 | 800 | 29 6 | 21 0 | 25 6 | | 56 | | 54½ |
| 31 | 2,315 | 1,366 | 30 0 | 18 0 | 24 7 | | 56 | | 53 |
| | 8,283 | 4,794 | 28 6 | 19 7 | 24 6 | | | | |

BARLEY—*continued.*

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | | Table of Bushel-weights for Lowest Price. | |
|---|---|---|---|---|---|---|---|---|---|
| 1894 | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb | lb. | lb. | lb. |
| Nov. | | | | | | | | | |
| 7 | 2,845 | 1,161 | 29 0 | 20 0 | 25 0 | | 56 | | 52½ |
| 14 | 2,772 | 1,103 | 30 0 | 18 0 | 24 5 | | 57 | | 50¾ |
| 21 | 2,624 | 1,161 | 28 6 | 20 0 | 24 11 | | 50½ | | 50 |
| 28 | 2,556 | 1,510 | 29 0 | 20 6 | 25 4 | | 56 | | 54½ |
| | 10,797 | 4,935 | 29 0 | 20 1 | 24 11 | | | | |
| Dec. | | | | | | | | | |
| 5 | 2,997 | 1,207 | 26 6 | 20 6 | 24 2 | 56½ | 57 | | 55 |
| 12 | 2,891 | 1,310 | 27 6 | 19 0 | 23 7 | | 56 | | 53½ |
| 19 | 2,460 | 1,237 | 28 6 | 17 0 | 23 6 | | 56½ | | 55 |
| 26 | 1,489 | 565 | 28 0 | 20 6 | 23 10 | | 55½ | | 55 |
| | 9,837 | 4,319 | 27 5 | 19 6 | 23 9 | | | | |
| Result for year | 59,524 | 20,091 | 30 6 | 22 9 | 27 0 | | | | |

## OATS.

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Bushel-weights for Highest Price. | | Bushel-weights for Lowest Price. | |
|---|---|---|---|---|---|---|---|---|---|
| 1894 | | | | | | | | | |
| Jan. | | | | | | | | | |
| 3 | 3,765 | 1,947 | 22 0 | 17 6 | 19 11 | | 45½ | 40½ | 42 |
| 10 | 3,680 | 2,920 | 22 0 | 17 6 | 20 0 | 44 | 44½ | | 42 |
| 17 | 4,151 | 2,318 | 22 6 | 17 0 | 19 10 | | 42 | | 42 |
| 24 | 4,016 | 2,412 | 21 0 | 16 6 | 19 11 | 44 | 45½ | 39 | 40 |
| 31 | 4,360 | 2,575 | 22 6 | 18 3 | 20 2 | | 40½ | | 41½ |
| | 19,972 | 12,172 | 21 4 | 17 6 | 20 0 | | | | |
| Feb. | | | | | | | | | |
| 7 | 3,964 | 2,204 | 21 6 | 17 0 | 19 8 | 44 | 45 | | 40 |
| 14 | 3,498 | 2,279 | 22 0 | 17 0 | 19 10 | 44½ | 45½ | | 40 |
| 21 | 3,863 | 1,403 | 23 0 | 17 0 | 20 0 | | 45½ | | 39¾ |
| 28 | 4,574 | 2,618 | 23 3 | 17 0 | 20 1 | | 45 | | 40 |
| | 15,899 | 8,504 | 21 10 | 17 0 | 19 11 | | | | |
| March | | | | | | | | | |
| 7 | 5,188 | 3,170 | 26 0 | 17 9 | 20 5 | | 44½ | | 42 |
| 14 | 4,190 | 2,303 | 24 0 | 17 8 | 20 5 | | 44½ | | 40 |
| 21 | 4,002 | 1,994 | 23 6 | 18 3 | 20 11 | | 41½ | | 40½ |
| 28 | 3,652 | 2,143 | 23 6 | 18 3 | 20 8 | | 46¾ | | 40½ |
| | 17,881 | 9,610 | 23 11 | 17 10 | 20 7 | | | | |
| April | | | | | | | | | |
| 4 | 3,258 | 2,468 | 23 0 | 17 9 | 21 2 | | 46½ | | 40 |
| 11 | 2,615 | 1,302 | 23 0 | 17 6 | 21 4 | 45 | 45¾ | | 38½ |
| 18 | 3,389 | 2,374 | 23 0 | 19 0 | 21 7 | 45 | 46½ | 41 | 42 |
| 25 | 3,626 | 2,019 | 22 9 | 19 0 | 21 3 | 45 | 45½ | | 42 |
| | 12,888 | 8,163 | 22 10 | 18 3 | 21 4 | | | | |
| May | | | | | | | | | |
| 2 | 3,607 | 1,982 | 23 3 | 18 3 | 21 3 | | 44½ | | 41 |
| 9 | 3,011 | 1,432 | 22 6 | 19 0 | 21 1 | | 44½ | 41 | 42 |
| 16 | 2,173 | 1,085 | 22 3 | 18 0 | 20 9 | | 44½ | 40 | 41 |
| 23 | 1,681 | 1,157 | 22 3 | 19 0 | 20 9 | | 45½ | 41 | 42½ |
| 30 | 1,374 | 1,179 | 22 9 | 18 0 | 21 3 | 44½ | 46 | | 40 |
| | 1,1796 | 6,835 | 22 9 | 18 6 | 21 1 | | | | |

OATS—*continued.*

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price | Table of Bushel-weights for Lowest Price. |
|---|---|---|---|---|---|---|---|
| 1894 June | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb. lb. | lb. lb. |
| 6 | 1,737 | 1,605 | 23 9 | 19 6 | 21 10 | 46¼ | 40 |
| 13 | 1,730 | 1,092 | 24 6 | 20 6 | 22 9 | 45½ | 42 43½ |
| 20 | 2,152 | 1,322 | 24 3 | 19 0 | 22 8 | 44½ 45¼ | 39¼ 41½ |
| 27 | 2,846 | 1,238 | 25 0 | 19 0 | 22 10 | 46 | 39½ |
| | 7,971 | 5,257 | 24 3 | 19 11 | 22 6 | | |
| July 4 | 1,886 | 1,476 | 25 3 | 20 0 | 23 0 | 44½ | 40¼ 42 |
| 11 | 2,744 | 1,782 | 25 9 | 21 0 | 23 5 | 45½ | 42 |
| 18 | 2,554 | 1,654 | 26 0 | 20 3 | 23 8 | 45 | 40 |
| 25 | 2,715 | 1,101 | 26 3 | 21 3 | 23 11 | 45 | 42 |
| | 9,899 | 6,068 | 25 11 | 20 10 | 23 4 | | |
| Aug. 1 | 3,526 | 1,238 | 26 3 | 21 0 | 24 0 | 45½ | 41 |
| 8 | 3,407 | 749 | 26 3 | 21 0 | 24 4 | 45½ 46 | 42 |
| 15 | 3,057 | 517 | 25 8 | 20 9 | 24 1 | 45½ | 42 |
| 22 | 2,215 | 1,010 | 24 9 | 21 0 | 23 8 | 44½ | 42 |
| 29 | 2,075 | 849 | 24 6 | 21 0 | 23 0 | 45 | 41 43 |
| | 14,343 | 4,367 | 25 6 | 21 0 | 23 10 | | |
| Sept. 5 | 2,339 | 1,418 | 24 0 | 18 0 | 21 8 | 44½ | 41 |
| 12 | 3,192 | 1,850 | 23 6 | 18 6 | 20 9 | 45½ | 42 |
| 19 | 2,744 | 2,022 | 22 9 | 16 6 | 20 0 | 44¼ | 42 |
| 26 | 2,206 | 1,017 | 22 9 | 15 0 | 19 8 | 45½ | 42 |
| | 10,571 | 6,062 | 23 3 | 16 0 | 20 6 | | |
| Oct. 3 | 3,164 | 2,286 | 22 6 | 14 0 | 19 5 | 42½ | 40 |
| 10 | 3,243 | 1,911 | 22 6 | 14 0 | 18 9 | 45 45½ | 40 |
| 17 | 2,707 | 2,045 | 22 6 | 15 0 | 18 8 | 42 47 | 41 43 |
| 24 | 2,914 | 1,903 | 22 9 | 13 6 | 19 1 | 45 | 39½ |
| 31 | 2,931 | 2,488 | 23 0 | 13 0 | 19 11 | 44 | 39½ |
| | 14,060 | 10,633 | 22 8 | 14 3 | 19 3 | | |
| Nov. 7 | 2,597 | 2,184 | 23 9 | 15 0 | 20 0 | 44½ | 42 |
| 14 | 2,568 | 2,081 | 24 0 | 14 0 | 20 5 | 46½ | 41 |
| 21 | 3,815 | 1,780 | 23 0 | 16 0 | 19 11 | 45 | 40½ |
| 28 | 3,972 | 1,327 | 24 0 | 14 0 | 19 3 | 44½ | 41 |
| | 12,952 | 7,331 | 23 7 | 14 9 | 19 11 | | |
| Dec. 5 | 4,013 | 1,611 | 21 3 | 14 0 | 19 2 | 44½ | 41 |
| 12 | 2,928 | 1,885 | 21 6 | 13 6 | 18 10 | 44¼ | 42 |
| 19 | 2,816 | 1,605 | 22 0 | 15 6 | 18 11 | 45½ | 42 |
| 26 | 1,792 | 1,038 | 22 3 | 14 0 | 19 1 | 45½ | 41 |
| | 11,549 | 6,144 | 21 8 | 14 6 | 19 0 | | |
| Result for year | 160,690 | 91,951 | 22 9 | 17 10 | 20 8 | | |

# BEANS.

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | Table of Bushel-weights for Lowest Price. |
|---|---|---|---|---|---|---|---|
| 1894 | Imp. qr. | Imp. qr. | s. d. | s. d. | s. d. | lb. lb. | lb. lb. |
| Jan. 3 | 47 | 22 | 31 6 | 30 0 | 30 4 | 65½ | 64½ |
| 10 | 32 | .. | .. | .. | .. | .. | .. |
| 17 | 62 | 46 | 32 0 | 30 0 | 30 10 | 66¼ | 63 63¼ |
| 24 | 164 | 34 | 34 0 | 30 0 | 30 9 | 65 | 64½ |
| 31 | 247 | 94 | 33 0 | 30 0 | 31 11 | 64½ | 64 |
| | 552 | 196 | 32 2 | 30 0 | 31 3 | | |
| Feb. 7 | 218 | 50 | 33 8 | 30 6 | 31 7 | 65½ | 64¼ |
| 14 | 338 | 120 | 36 0 | 30 0 | 32 5 | 64½ | 65½ |
| 21 | 426 | 170 | 35 0 | 30 0 | 31 9 | 66 | 65¼ |
| 28 | 300 | 159 | 37 6 | 29 0 | 31 8 | 64½ | 62½ |
| | 1,282 | 499 | 35 1 | 29 11 | 31 0 | | |
| March 7 | 107 | 43 | 34 6 | 28 0 | 31 10 | 65½ | 60½ |
| 14 | 178 | 57 | 33 0 | 30 0 | 31 0 | 65¼ | 63 64½ |
| 21 | 227 | 19 | 32 6 | 30 0 | 30 9 | 66 | 64 |
| 28 | 237 | 45 | 33 6 | 29 0 | 30 9 | 65½ | 64 |
| | 889 | 164 | 33 9 | 29 7 | 31 2 | | |
| April 4 | 210 | 45 | 32 0 | 29 3 | 29 11 | 65 | 63 |
| 11 | 209 | 84 | 31 6 | 28 6 | 29 11 | 66 | 63 |
| 18 | 136 | 5 | 30 0 | .. | 30 0 | 65½ | .. |
| 25 | 76 | 18 | 31 0 | .. | 31 0 | 66 | .. |
| | 631 | 147 | 31 1 | 28 10 | 30 0 | | |
| May 2 | 33 | .. | .. | .. | .. | .. | .. |
| 9 | 48 | 32 | 29 6 | 29 0 | 29 5 | 64 | 63¾ |
| 16 | 14 | .. | .. | . | .. | .. | .. |
| 23 | 28 | . | .. | .. | .. | .. | .. |
| 30 | 14 | 14 | 32 8 | .. | 32 8 | 60½ | .. |
| | 137 | 46 | 30 6 | 29 0 | 30 8 | | |
| June 6 | 23 | .. | .. | .. | .. | .. | .. |
| 13 | 13 | 13 | 33 0 | . | 33 0 | 66 | .. |
| 20 | 34 | 4 | 29 0 | . | 29 0 | 64½ | .. |
| 27 | 21 | 5 | 30 6 | .. | 30 6 | 63 | .. |
| | 91 | 22 | 31 8 | | 31 8 | | |
| July 4 | 31 | 31 | 32 8 | 28 6 | 30 5 | 66¼ | 62 |
| 11 | 7 | . | .. | .. | .. | .. | .. |
| 18 | .. | .. | .. | .. | .. | .. | .. |
| 25 | 10 | 10 | 29 0 | .. | 29 0 | 63 | .. |
| | 48 | 41 | 31 0 | 28 6 | 30 1 | | |
| Aug. 1 | .. | .. | .. | | .. | .. | .. |
| 8 | 10 | 10 | 30 6 | .. | 30 6 | 63 | .. |
| 15 | 27 | 7 | 33 6 | . | 33 0 | 66½ | .. |
| 22 | 30 | 5 | 31 6 | . | 31 6 | 63 | .. |
| 29 | 26 | .. | .. | .. | .. | .. | .. |
| | 93 | 22 | 31 8 | .. | 31 8 | | |

BEANS—*continued.*

| Date. | Quantity offered for Sale. | Quantity Sold. | Highest Price. | Lowest Price. | Average Price. | Table of Bushel-weights for Highest Price. | Table of Bushel-weights for Lowest Price. |
|---|---|---|---|---|---|---|---|
| 1894 Sept. | Imp. qr. | Imp. qr. | *s. d.* | *s. d.* | *s. d.* | lb. lb. | lb. lb. |
| 5 | 20 | .. | .. | .. | .. | .. | .. |
| 12 | 10 | 10 | 31 0 | .. | 31 0 | 63 | .. |
| 19 | 20 | 20 | 33 6 | .. | 33 6 | 65½ | .. |
| 26 | 8 | 8 | 32 6 | .. | 32 6 | 64 | .. |
| | 58 | 38 | 32 8 | .. | 32 8 | | |
| Oct. 3 | .. | .. | .. | .. | .. | .. | .. |
| 10 | 6 | 6 | 34 0 | .. | 34 0 | 65½ | .. |
| 17 | .. | .. | .. | .. | .. | .. | .. |
| 24 | 21 | 21 | 27 0 | . | 27 0 | 63 | .. |
| 31 | .. | .. | .. | .. | .. | .. | .. |
| | 27 | 27 | 28 7 | .. | 28 7 | | |
| Nov. 7 | .. | .. | .. | .. | .. | .. | .. |
| 14 | 23 | 16 | 29 6 | .. | 29 6 | 64½ | .. |
| 21 | 7 | 7 | 34 6 | 34 0 | 34 3 | 65½ | 65½ |
| 28 | 35 | 5 | 29 0 | .. | 29 0 | 63 | .. |
| | 65 | 28 | 30 0 | 34 0 | 30 7 | | |
| Dec. 5 | 9 | 9 | 29 0 | .. | 29 0 | 65 | .. |
| 12 | 30 | .. | .. | .. | .. | .. | .. |
| 19 | 30 | .. | .. | .. | .. | .. | .. |
| 26 | 30 | 5 | 28 6 | .. | 28 6 | 63 | . |
| | 99 | 14 | 28 9 | .. | 28 9 | | |
| Result for year | 3,972 | 1,244 | 31 8 | 29 7 | 31 2 | | |

PRICES OF SHEEP SINCE 1818. TABLE NO. 1.—CHEVIOT SHEEP.

| Year. | Wethers. | | | | | Ewes. | | | | | Lambs. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | s. | d. | | s. | d. | s. | d. | | s. | d. | s. | d. | | s. | d. |
| 1818 | 28 | 0 | to | 30 | 0 | not quoted. | | | | | 8 | 0 | to | 10 | 0 |
| 1819 | 25 | 0 | " | 27 | 0 | 15 | 0 | to | 17 | 0 | 10 | 6 | " | 12 | 0 |
| 1820 | 20 | 0 | " | 25 | 0 | 16 | 0 | " | 17 | 0 | 10 | 0 | " | 11 | 0 |
| 1821 | 18 | 0 | " | 20 | 0 | 14 | 0 | " | 16 | 0 | 7 | 6 | " | 8 | 0 |
| 1822 | 12 | 6 | " | 18 | 0 | 8 | 0 | " | 8 | 6 | 4 | 6 | " | 0 | 0 |
| 1823 | 13 | 6 | " | 18 | 0 | 7 | 0 | " | 10 | 6 | 5 | 6 | " | 6 | 0 |
| 1824 | 14 | 0 | " | 19 | 0 | 7 | 0 | " | 9 | 0 | 4 | 6 | " | 6 | 0 |
| 1825 | 29 | 0 | " | 32 | 0 | 15 | 0 | " | 19 | 0 | 9 | 0 | " | 10 | 6 |
| 1826 | 17 | 6 | " | 21 | 6 | 18 | 0 | " | 15 | 0 | 7 | 0 | " | 7 | 6 |
| 1827 | 15 | 0 | " | 24 | 0 | not quoted. | | | | | 7 | 0 | " | 8 | 0 |
| 1828 | 18 | 0 | " | 27 | 0 | 12 | 0 | to | 15 | 0 | 7 | 0 | " | 8 | 3 |
| 1829 | 18 | 0 | " | 24 | 0 | 12 | 6 | " | 14 | 0 | 7 | 0 | " | 8 | 6 |
| 1830 | 15 | 0 | " | 21 | 0 | 8 | 0 | " | 11 | 0 | 6 | 0 | " | 6 | 9 |
| 1831 | 18 | 0 | " | 25 | 0 | 9 | 0 | " | 18 | 0 | 7 | 0 | " | 8 | 0 |
| 1832 | 19 | 0 | " | 24 | 0 | 11 | 0 | " | 16 | 0 | 7 | 0 | " | 9 | 0 |
| 1833 | 22 | 0 | " | 31 | 0 | 13 | 6 | " | 20 | 0 | 8 | 0 | " | 11 | 8 |
| 1834 | 22 | 0 | " | 31 | 0 | 18 | 6 | " | 21 | 0 | 9 | 0 | " | 11 | 0 |
| 1835 | 22 | 0 | " | 27 | 6 | 18 | 0 | " | 20 | 6 | 8 | 0 | " | 11 | 0 |
| 1836 | 24 | 0 | " | 31 | 6 | 16 | 0 | " | 19 | 0 | 10 | 0 | " | 14 | 0 |
| 1837 | 19 | 0 | " | 28 | 0 | 14 | 0 | " | 19 | 0 | 10 | 0 | " | 13 | 0 |
| 1838 | 23 | 0 | " | 30 | 6 | 17 | 0 | " | 22 | 0 | 12 | 0 | " | 14 | 0 |
| 1839 | 23 | 0 | " | 31 | 0 | 14 | 0 | " | 19 | 0 | 9 | 0 | " | 18 | 0 |
| 1840 | 24 | 0 | " | 33 | 0 | 15 | 0 | " | 23 | 0 | 7 | 0 | " | 11 | 6 |
| 1841 | 23 | 0 | " | 30 | 0 | 14 | 0 | " | 22 | 0 | 8 | 0 | " | 12 | 0 |
| 1842 | 22 | 6 | " | 28 | 0 | 13 | 0 | " | 17 | 0 | 7 | 6 | " | 10 | 0 |
| 1843 | 19 | 0 | " | 25 | 0 | 8 | 0 | " | 12 | 0 | 5 | 0 | " | 8 | 0 |
| 1844 | 21 | 0 | " | 29 | 0 | 10 | 0 | " | 16 | 0 | 8 | 0 | " | 10 | 6 |
| 1845 | 28 | 0 | " | 33 | 0 | 13 | 0 | " | 20 | 0 | 8 | 0 | " | 13 | 0 |
| 1846 | 24 | 0 | " | 33 | 6 | 14 | 0 | " | 21 | 6 | 10 | 0 | " | 14 | 6 |
| 1847 | 24 | 0 | " | 35 | 0 | 13 | 0 | " | 24 | 0 | 11 | 0 | " | 15 | 0 |
| 1848 | 23 | 0 | " | 34 | 6 | 13 | 0 | " | 23 | 0 | 11 | 6 | " | 15 | 0 |
| 1849 | 21 | 0 | " | 30 | 2 | 12 | 0 | " | 21 | 0 | 9 | 0 | " | 14 | 0 |
| 1850 | 20 | 0 | " | 29 | 6 | 12 | 0 | " | 20 | 0 | 8 | 0 | " | 13 | 0 |
| 1851 | 21 | 6 | " | 31 | 0 | 13 | 0 | " | 21 | 0 | 8 | 9 | " | 14 | 0 |
| 1852 | 21 | 0 | " | 32 | 0 | 15 | 0 | " | 23 | 0 | 8 | 0 | " | 14 | 0 |
| 1853 | 26 | 6 | " | 38 | 0 | 17 | 0 | " | 28 | 6 | 9 | 0 | " | 17 | 0 |
| 1854 | 25 | 0 | " | 36 | 0 | 17 | 0 | " | 26 | 0 | 9 | 0 | " | 16 | 6 |
| 1855 | 28 | 6 | " | 36 | 0 | 16 | 0 | " | 25 | 0 | 10 | 0 | " | 17 | 0 |
| 1856 | 22 | 0 | " | 35 | 6 | 15 | 6 | " | 24 | 0 | 10 | 0 | " | 15 | 0 |
| 1857 | 24 | 0 | " | 36 | 0 | 14 | 6 | " | 26 | 0 | 10 | 6 | " | 14 | 6 |
| 1858 | 24 | 0 | " | 34 | 6 | 14 | 0 | " | 24 | 6 | 10 | 6 | " | 14 | 0 |
| 1859 | 25 | 0 | " | 34 | 6 | 16 | 0 | " | 25 | 0 | 10 | 3 | " | 14 | 9 |
| 1860 | 26 | 0 | " | 38 | 0 | 17 | 6 | " | 27 | 6 | 12 | 6 | " | 17 | 6 |
| 1861 | 25 | 0 | " | 38 | 6 | 16 | 0 | " | 28 | 0 | 9 | 0 | " | 16 | 0 |
| 1862 | 27 | 0 | " | 37 | 6 | 17 | 6 | " | 28 | 0 | 10 | 0 | " | 16 | 0 |
| 1863 | 25 | 0 | " | 38 | 6 | 19 | 0 | " | 28 | 6 | 10 | 6 | " | 16 | 0 |
| 1864 | 31 | 0 | " | 41 | 0 | 21 | 0 | " | 31 | 6 | 14 | 0 | " | 18 | 0 |
| 1865 | 32 | 6 | " | 44 | 0 | 22 | 6 | " | 33 | 6 | 14 | 0 | " | 20 | 0 |
| 1866 | 37 | 0 | " | 50 | 0 | 20 | 0 | " | 42 | 6 | 15 | 0 | " | 20 | 0 |
| 1867 | 26 | 0 | " | 58 | 0 | 18 | 0 | " | 25 | 6 | 12 | 0 | " | 16 | 0 |
| 1868 | 30 | 0 | " | 32 | 0 | 15 | 6 | " | 21 | 0 | 7 | 6 | " | 13 | 0 |
| 1869 | 28 | 0 | " | 38 | 0 | 15 | 0 | " | 22 | 6 | 7 | 6 | " | 14 | 0 |
| 1870 | 35 | 6 | " | 43 | 0 | 18 | 0 | " | 28 | 0 | 10 | 0 | " | 17 | 0 |
| 1871 | 36 | 6 | " | 49 | 0 | 22 | 0 | " | 33 | 6 | 11 | 0 | " | 20 | 0 |
| 1872 | 45 | 0 | " | 56 | 0 | 32 | 0 | " | 42 | 0 | 16 | 0 | " | 22 | 0 |
| 1873 | 42 | 0 | " | 51 | 0 | 25 | 0 | " | 42 | 0 | 15 | 6 | " | 22 | 0 |
| 1874 | 33 | 6 | " | 44 | 6 | 21 | 0 | " | 36 | 0 | 12 | 0 | " | 17 | 0 |
| 1875 | 33 | 0 | " | 48 | 6 | 21 | 0 | " | 34 | 0 | 13 | 6 | " | 23 | 6 |
| 1876 | 40 | 0 | " | 52 | 6 | 23 | 0 | " | 30 | 0 | 13 | 6 | " | 25 | 0 |
| 1877 | 41 | 0 | " | 51 | 0 | 25 | 0 | " | 37 | 0 | 15 | 0 | " | 21 | 0 |
| 1878 | 35 | 6 | " | 48 | 0 | 23 | 6 | " | 35 | 0 | 14 | 0 | " | 22 | 0 |
| 1879 | 34 | 0 | " | 44 | 0 | 21 | 0 | " | 34 | 0 | 14 | 0 | " | 20 | 0 |
| 1880 | 30 | 0 | " | 43 | 6 | 20 | 0 | " | 30 | 0 | 12 | 6 | " | 20 | 0 |
| 1881 | 32 | 0 | " | 45 | 6 | 29 | 0 | " | 34 | 0 | 14 | 0 | " | 20 | 0 |
| 1882 | 40 | 0 | " | 51 | 0 | 30 | 0 | " | 40 | 0 | 14 | 0 | " | 20 | 6 |
| 1883 | 44 | 0 | " | 55 | 6 | 34 | 6 | " | 46 | 6 | 15 | 6 | " | 23 | 0 |
| 1884 | 36 | 0 | " | 47 | 6 | 29 | 6 | " | 41 | 6 | 12 | 0 | " | 20 | 0 |
| 1885 | 30 | 0 | " | 38 | 0 | 24 | 0 | " | 31 | 0 | 12 | 0 | " | 18 | 0 |
| 1886 | 32 | 0 | " | 40 | 0 | 21 | 0 | " | 29 | 0 | 12 | 6 | " | 19 | 0 |
| 1887 | 29 | 0 | " | 36 | 0 | 18 | 0 | " | 26 | 0 | 11 | 0 | " | 16 | 6 |
| 1888 | 30 | 0 | " | 38 | 0 | 19 | 0 | " | 27 | 0 | 12 | 0 | " | 17 | 6 |
| 1889 | 36 | 0 | " | 44 | 0 | 24 | 0 | " | 32 | 0 | 14 | 0 | " | 22 | 0 |
| 1890 | 31 | 0 | " | 40 | 0 | 22 | 0 | " | 30 | 0 | 12 | 6 | " | 20 | 0 |
| 1891 | 27 | 0 | " | 38 | 0 | 16 | 0 | " | 25 | 0 | 9 | 0 | " | 16 | 0 |
| 1892 | 22 | 0 | " | 30 | 6 | 13 | 0 | " | 22 | 0 | 5 | 0 | " | 11 | 0 |
| 1893 | 26 | 0 | " | 35 | 6 | 18 | 0 | " | 28 | 6 | 8 | 6 | " | 15 | 0 |
| 1894 | 20 | 0 | " | 37 | 0 | 20 | 0 | " | 31 | 0 | 10 | 6 | " | 18 | 6 |

## Table No. 2.—BLACKFACED SHEEP.

| Year. | Wethers. | Ewes. | Lambs. |
|---|---|---|---|
| | s. d. s. d. | s. d. s. d. | s. d. s. d. |
| 1819 | 22 0 to 24 0 | 12 0 to 15 0 | 8 0 to 9 0 |
| 1820 | 20 0 " 23 8 | 15 6 " 17 0 | 7 0 " 8 6 |
| 1821 | 18 0 " 20 0 | 12 0 " 13 0 | 6 0 " 7 0 |
| 1822 | 11 6 " 13 6 | 5 6 " 6 0 | 4 6 " 0 0 |
| 1823 | 12 0 " 16 0 | 5 0 " 6 6 | 4 0 " 5 8 |
| 1824 | 9 6 " 18 6 | 6 0 " 7 0 | 4 0 " 5 0 |
| 1825 | 22 0 " 26 0 | 11 0 " 18 6 | 6 0 " 9 0 |
| 1826 | 15 0 " 17 0 | 8 0 " 9 0 | 4 6 " 6 0 |
| 1827 | 14 0 " 18 6 | 7 0 " 10 0 | 0 0 " 7 6 |
| 1828 | 15 0 " 20 0 | 8 0 " 11 0 | 5 0 " 7 6 |
| 1829 | 14 0 " 18 0 | 9 0 " 10 0 | 6 0 " 7 0 |
| 1830 | 9 6 " 18 0 | 4 0 " 6 0 | 4 6 " 6 0 |
| 1831 | 13 0 " 17 0 | 5 0 " 7 6 | 5 0 " 6 6 |
| 1832 | 14 0 " 18 0 | 7 0 " 11 6 | 6 0 " 7 8 |
| 1833 | 16 0 " 24 0 | 7 6 " 12 0 | 6 6 " 0 0 |
| 1834 | 16 0 " 22 0 | 10 0 " 13 0 | 6 0 " 8 6 |
| 1835 | 15 0 " 18 9 | 10 0 " 13 0 | 7 0 " 8 0 |
| 1836 | 15 0 " 21 0 | 9 0 " 12 0 | 8 6 " 11 0 |
| 1837 | 13 0 " 16 0 | 8 0 " 12 0 | 8 0 " 9 6 |
| 1838 | 15 0 " 20 6 | 10 0 " 13 0 | not quoted. |
| 1839 | 15 0 " 22 0 | 10 0 " 12 0 | 7 0 to 8 3 |
| 1840 | 13 0 " 22 6 | 11 0 " 12 0 | 7 0 " 9 3 |
| 1841 | 16 0 " 20 0 | 9 0 " 11 0 | 6 0 " 8 0 |
| 1842 | 14 0 " 19 0 | 7 6 " 8 0 | 5 6 " 7 0 |
| 1843 | not quoted. | 4 9 " 6 6 | not quoted. |
| 1844 | 15 0 to 21 0 | 6 6 " 10 0 | 5 0 to 8 0 |
| 1845 | 14 0 " 23 0 | 8 0 " 12 0 | 6 0 " 8 0 |
| 1846 | 13 0 " 24 0 | 10 0 " 13 0 | 8 0 " 9 0 |
| 1847 | 20 6 " 25 0 | 10 0 " 14 0 | 8 6 " 9 6 |
| 1848 | 20 0 " 24 0 | 11 3 " 12 0 | 8 6 " 10 0 |
| 1849 | not quoted. | not quoted. | 7 0 " 7 6 |
| 1850 | .. | .. | 7 0 " 0 0 |
| 1851 | 17 6 to 23 0 | 9 0 to 12 0 | 6 6 " 8 0 |
| 1852 | 18 6 " 22 0 | 9 6 " 12 0 | 4 6 " 7 0 |
| 1853 | 23 0 " 27 0 | 14 6 " 16 6 | 8 0 " 11 6 |
| 1854 | 20 0 " 26 0 | 11 0 " 16 6 | 8 0 " 10 6 |
| 1855 | 23 6 " 26 6 | 14 0 " 16 0 | 10 0 " 11 0 |
| 1856 | 17 0 " 24 0 | 10 0 " 20 0 | 7 6 " 10 0 |
| 1857 | 20 0 " 29 0 | 10 6 " 15 0 | 9 3 " 11 0 |
| 1858 | 20 0 " 27 0 | 9 9 " 18 9 | 8 3 " 10 6 |
| 1859 | 20 0 " 25 0 | 10 0 " 14 0 | 8 9 " 11 0 |
| 1860 | 21 0 " 27 3 | 11 0 " 16 0 | 10 0 " 13 6 |
| 1861 | 21 0 " 29 0 | 12 0 " 22 0 | 6 3 " 14 0 |
| 1862 | 16 9 " 27 0 | 12 0 " 18 8 | 6 0 " 12 0 |
| 1863 | 20 0 " 30 6 | 13 0 " 16 0 | 8 0 " 11 6 |
| 1864 | 25 0 " 30 0 | 15 0 " 19 0 | 10 0 " 13 6 |
| 1865 | 15 6 " 32 6 | 15 0 " 25 0 | 10 0 " 17 0 |
| 1866 | 31 6 " 40 0 | 20 0 " 30 0 | 13 6 " 22 6 |
| 1867 | 20 0 " 30 6 | 14 0 " 22 0 | 7 6 " 13 6 |
| 1868 | 20 0 " 26 0 | 10 6 " 18 6 | 7 0 " 18 0 |
| 1869 | 22 0 " 28 0 | 11 0 " 14 0 | 6 9 " 9 0 |
| 1870 | 27 0 " 33 6 | 13 0 " 22 0 | 8 0 " 14 6 |
| 1871 | 23 0 " 37 0 | 13 0 " 23 0 | 11 0 " 16 3 |
| 1872 | 31 6 " 45 0 | 18 0 " 32 0 | 12 6 " 18 0 |
| 1873 | 28 0 " 39 0 | 16 6 " 27 0 | 7 0 " 10 0 |
| 1874 | 25 0 " 35 0 | 13 0 " 20 0 | 7 0 " 14 0 |
| 1875 | 26 6 " 37 6 | 15 0 " 21 3 | 9 6 " 17 6 |
| 1876 | 30 0 " 40 0 | 19 0 " 24 0 | 13 0 " 20 6 |
| 1877 | 35 0 " 38 9 | 18 0 " 25 0 | 13 6 " 23 0 |
| 1878 | 30 0 " 36 0 | 17 0 " 23 0 | 12 0 " 22 0 |
| 1879 | 25 0 " 35 9 | 16 0 " 24 0 | 10 6 " 20 0 |
| 1880 | 25 0 " 38 0 | 16 6 " 22 6 | 10 0 " 17 0 |
| 1881 | 30 0 " 39 0 | 15 0 " 23 0 | 10 0 " 15 0 |
| 1882 | 33 0 " 46 0 | 20 0 " 28 0 | 12 6 " 18 6 |
| 1883 | 36 0 " 50 6 | 24 6 " 33 0 | 14 0 " 21 6 |
| 1884 | 29 0 " 43 6 | 19 6 " 28 0 | 12 0 " 19 6 |
| 1885 | 24 0 " 34 0 | 13 0 " 22 6 | 10 0 " 15 0 |
| 1886 | 25 0 " 34 0 | 12 0 " 22 0 | 10 6 " 16 0 |
| 1887 | 22 0 " 30 0 | 11 0 " 19 0 | 8 0 " 13 0 |
| 1888 | 22 0 " 32 0 | 13 0 " 24 0 | 10 0 " 15 0 |
| 1889 | 26 0 " 40 0 | 18 0 " 29 0 | 13 0 " 22 0 |
| 1890 | 24 0 " 37 0 | 14 0 " 27 0 | 10 6 " 19 0 |
| 1891 | 21 0 " 37 0 | 10 0 " 24 0 | 7 6 " 15 0 |
| 1892 | 16 0 " 28 6 | 6 0 " 17 0 | 8 0 " 10 0 |
| 1893 | 21 0 " 37 0 | 12 0 " 24 0 | 7 0 " 14 6 |
| 1894 | 20 0 " 37 6 | 14 6 " 26 6 | 8 6 " 16 0 |

Table No. 3.—PRICE OF WOOL, per stone of 24 lb., since 1818.

| Year. | Laid Cheviot. | White Cheviot. | Laid Highland. | White Highland. |
|---|---|---|---|---|
| | s. d. s. d. | s. d. s. d. | s. d. s. d. | s. d. s. d. |
| 1818 | 40 0 to 42 2 | .. | 20 0 to 22 6 | .. |
| 1819 | 21 0 " 22 0 | .. | 10 0 " 10 8 | .. |
| 1820 | 20 0 " 22 0 | .. | 9 0 " 10 0 | .. |
| 1821 | 18 0 " 20 0 | .. | 9 0 " 10 0 | .. |
| 1822 | 12 6 " 14 6 | .. | 5 0 " 6 6 | .. |
| 1823 | 9 0 " 10 6 | .. | 5 0 " 5 9 | .. |
| 1824 | 18 6 " 15 0 | . | 6 0 " 6 8 | .. |
| 1825 | 10 6 " 22 0 | . | 10 0 " 10 6 | . |
| 1826 | 11 0 " 14 0 | .. | 5 0 " 5 6 | .. |
| 1827 | 11 0 " 14 0 | .. | 5 6 " 6 9 | .. |
| 1828 | 8 0 " 11 0 | .. | 5 6 " 6 0 | .. |
| 1829 | 8 6 " 11 0 | .. | 4 8 " 0 0 | .. |
| 1830 | 9 6 " 11 0 | .. | 4 6 " 5 0 | .. |
| 1831 | 17 0 " 20 0 | .. | 7 6 " 8 6 | .. |
| 1832 | 14 0 " 16 0 | .. | 7 0 " 7 6 | .. |
| 1833 | 18 0 " 20 7 | .. | 10 0 " 11 0 | .. |
| 1834 | 21 0 " 24 6 | .. | 5 6 " 7 0 | .. |
| 1835 | 19 0 " 20 6 | .. | 9 6 " 10 8 | .. |
| 1836 | 21 0 " 25 0 | .. | 10 0 " 14 0 | .. |
| 1837 | 12 0 " 14 0 | .. | 7 0 " 7 8 | .. |
| 1838 | 10 0 " 23 6 | .. | 6 0 " 10 0 | .. |
| 1839 | 18 0 " 20 0 | .. | 8 0 " 12 0 | .. |
| 1840 | 15 0 " 0 0 | .. | 7 0 " 0 0 | .. |
| 1841 | 15 0 " 16 0 | . | 6 0 " 7 5 | .. |
| 1842 | 12 6 " 14 0 | .. | not quoted. | .. |
| 1843 | 9 0 " 11 6 | . | 5 0 to 6 0 | .. |
| 1844 | 15 0 " 18 0 | . | not quoted. | .. |
| 1845 | 14 6 " 17 6 | .. | 7 6 to 8 6 | .. |
| 1846 | 12 0 " 14 6 | .. | 8 0 " 8 6 | .. |
| 1847 | 12 6 " 14 0 | .. | not quoted. | |
| 1848 | 9 6 " 11 0 | .. | 4 9 to 0 0 | .. |
| 1849 | 12 0 " 16 6 | .. | 6 0 " 6 8 | .. |
| 1850 | 15 0 " 17 6 | .. | 8 0 " 8 6 | |
| 1851 | 12 0 " 16 0 | .. | 8 0 " 9 3 | .. |
| 1852 | 13 0 " 15 0 | .. | 8 0 " 0 0 | .. |
| 1853 | 19 0 " 22 0 | . | 11 0 " 12 0 | .. |
| 1854 | 12 0 " 15 0 | . | 7 6 " 8 6 | .. |
| 1855 | 14 6 " 19 0 | .. | 8 6 " 0 0 | .. |
| 1856 | 10 0 " 21 6 | . | 11 0 " 0 0 | .. |
| 1857 | 19 0 " 24 0 | . | 13 0 " 14 3 | .. |
| 1858 | 15 0 " 17 0 | .. | 8 9 " 10 0 | .. |
| 1859 | 18 6 " 24 0 | .. | 10 9 " 11 6 | .. |
| 1860 | 22 0 " 32 0 | 37 0 to 38 0 | 10 0 " 11 3 | .. |
| 1861 | 19 6 " 27 0 | from 30s. upwards. | not quoted. | .. |
| 1862 | 18 6 " 26 0 | 30 0 to 37 0 | 11 6 to 16 0 | .. |
| 1863 | 25 6 " 31 0 | 38 0 " 42 0 | 15 3 " 17 6 | .. |
| 1864 | 31 0 " 39 0 | 47 0 " 54 0 | 17 6 " 20 0 | .. |
| 1865 | 23 0 " 30 0 | 44 0 " 45 0 | 15 0 " 17 0 | .. |
| 1866 | 24 0 " 30 0 | 30 0 " 38 0 | 14 0 " 16 0 | .. |
| 1867 | 16 0 " 21 6 | not quoted. | not quoted. | .. |
| 1868 | 19 0 " 20 0 | 28 0 to 32 0 | 8 6 to 9 0 | .. |
| 1869 | 18 0 " 20 6 | not quoted. | 8 6 " 10 0 | .. |
| 1870 | 15 0 " 23 6 | 25 0 to 26 0 | 9 6 " 0 0 | .. |
| 1871 | 20 0 " 26 6 | 30 0 " 31 6 | 12 0 " 15 0 | .. |
| 1872 | 26 0 " 37 6 | 40 0 " 48 0 | 18 0 " 21 0 | .. |
| 1873 | 17 0 " 18 0 | 34 0 " 40 0 | 9 0 " 12 0 | .. |
| 1874 | 18 6 " 26 6 | 30 0 " 34 0 | 9 6 " 13 0 | .. |
| 1875 | 25 0 " 32 0 | 34 6 " 36 0 | 12 6 " 16 0 | .. |
| 1876 | 20 0 " 24 0 | 30 0 " 31 6 | 9 6 " 12 0 | . |
| 1877 | 20 9 " 26 0 | 28 0 " 30 0 | 10 0 " 12 0 | .. |
| 1878 | 18 9 " 25 0 | 27 0 " 32 0 | 8 6 " 11 6 | .. |
| 1879 | 15 0 " 17 0 | prices very low. | 7 0 " 0 0 | .. |
| 1880 | 20 0 " 24 0 | 30 0 to 32 0 | 10 6 " 11 6 | 14 0 to 15 0 |
| 1881 | 17 0 " 21 0 | 27 0 " 30 0 | 5 0 " 9 6 | 12 0 " 13 0 |
| 1882 | 14 0 " 18 0 | 27 6 " 28 0 | 7 6 " 9 0 | 13 0 " 14 0 |
| 1883 | 18 0 " 18 0 | 26 0 " 28 0 | 6 6 " 8 6 | 11 6 " 12 6 |
| 1884 | 13 0 " 18 0 | 26 0 " 28 0 | 6 6 " 8 6 | 11 6 " 12 6 |
| 1885 | 12 0 " 17 0 | 22 6 " 26 0 | 6 0 " 8 0 | 11 6 " 12 0 |
| 1886 | 18 0 " 18 0 | 23 0 " 27 6 | 6 6 " 8 6 | 11 6 " 12 0 |
| 1887 | 14 0 " 22 0 | 23 0 " 28 0 | 7 0 " 9 0 | 11 6 " 13 0 |
| 1888 | 13 0 " 20 0 | 23 0 " 28 0 | 7 0 " 9 0 | 11 0 " 12 6 |
| 1889 | 13 0 " 18 0 | 24 0 " 28 0 | 7 0 " 9 0 | 11 0 " 12 6 |
| 1890 | 18 0 " 18 0 | 24 0 " 28 0 | 7 0 " 9 0 | 11 0 " 12 6 |
| 1891 | 12 6 " 18 0 | 22 0 " 28 0 | 7 0 " 9 0 | 11 0 " 12 6 |
| 1892 | 12 0 " 18 0 | 20 0 " 28 0 | 7 0 " 8 6 | 10 6 " 12 0 |
| 1893 | 12 0 " 17 0 | 20 0 " 27 0 | 7 0 " 8 0 | 10 0 " 12 0 |
| 1894 | 12 0 " 16 0 | 20 0 " 26 0 | 7 0 " 8 0 | 10 0 " 12 0 |

# CHEMICAL DEPARTMENT.

## PUMPHERSTON EXPERIMENTAL STATION.

### THE PERMANENT EFFECTS OF MANURES UPON MEADOW-LAND, AS SHOWN BY THE RELATIVE ABUNDANCE OF GRASS AND CLOVER IN THE PASTURE, AND THE MANNER IN WHICH IT IS EATEN BY STOCK.

In 1893 the experiments on the effect of various manures upon grass, both as regards quantity and quality, came to an end. The farm of Pumpherston passed out of the possession of Mr M'Lagan, who had leased the field to the Society, and was let to Mr Miller, who informed the Society that he intended to leave the field lying in grass for a year and to graze it with cows and horses. It appeared to the Chemical Committee that some additional information might be got by noting how the stock depastured the various plots which had for fourteen years been manured with a variety of manures in a definite manner.

Mr Miller expressed his desire that full advantage should be taken by the Society of whatever further information the field could thus afford, and took a personal interest in the observations.

I visited the field on three occasions—viz., in the middle of June, the beginning of August, and the middle of September—and, along with my assistant, carefully examined each plot, and assigned a comparative value to it under three distinct counts—first, as regards the abundance of grass; second, as regards the abundance of clover; and third, as to the extent to which the stock had eaten the pasture.

The method of valuation was to affix the value of 100 to a plot on which a completely filled-in sole of grass was growing; also to value at 100 any plot to which clover had taken thick and regular possession of the pasture; and lastly, to value at 100 any plot which had been eaten down quite bare, and to affix smaller values according as the grasses and clovers were

deficient and the herbage uneaten. On the second and third occasions the valuations were made quite independently of the former valuations, and without knowing what they had been. The result is that the standard of valuation on the three occasions has perhaps been different—that is to say, it may have been pitched somewhat higher or lower on one occasion than on another; but however that may be, at least the relative values assigned on each occasion were uninfluenced by the previous valuations.

These percentage values are contained on Tables I., II., and III. (pp. 429, 430, 431), and a summary of the whole on Table IV. (p. 432). No manure was applied to the grass by Mr Miller, so that the observations refer to the residual fertility of the manures after crops of hay had been regularly removed.

It will be seen from Table I. that the relative abundance of grasses proper does not vary nearly so much as does that of clover in Table II., or as what may be called the relative palatability or attractiveness as indicated by the values in Table III.

The grasses proper gradually thickened up as the season went on, especially on those plots which used to be manured with the slower-acting manures, or to which incomplete manures had been applied. The clover for the most part attained its maximum in August. The only clover on the field was the white clover.

Among the phosphate plots, as they used to be called (plots 1 to 12), the most satisfactory in every way were those to which bone-meal in some form had been applied. When cut for hay these plots were always disappointing; and indeed they were in no way superior to the plot that got no phosphates, but which had its nitrogen in the form of nitrate of soda. The slow action of the nitrogenous matter of bone-meal was the cause of its being so poor a manure for a hay crop. When we come to view it as a pasture manure it takes a very different position. Not only did it produce good grass but also abundance of clover, and the stock visited it every day, and were more assiduous in their attention to it as the season progressed. The slowly-acting nitrogenous matter supplied the plants in a steady measure; and that supply was doubtless derived in part from the application of bone manure during many preceding years. They were among the freshest, greenest, and most barely eaten plots on the station.

Had the other phosphate plots been manured with nitrate as usual, they would have shown a display of grass but comparatively little clover. The abundance of clover on the first three plots marked them out very distinctly. By no immediate application of manure could the neighbouring plots have

matched the bone plots in clover, for the plants were not there. The green colour of these plots was not due to the abundance of clover alone, for the grass growing among the clover was of a finer green than on the other plots where the grasses proper were equally abundant, but where the clover was scarce. No better illustration of the reality and of the value of symbiosis could have been desired than was presented by the fine colour and vigour of the grasses on those plots where the clover was thick, and their pale and drooping habit on those where the clover was scarce. It was quite evident that one function of the clover was to provide nitrogen for the nourishment of the grasses.

The plots where ground mineral phosphates used to be applied (plot 9) had a good sole of grass, but the stock did not like it, and they liked the adjoining plot (No. 10) even less. Superphosphate produced more hay in the past than the ground mineral phosphate, but the ground phosphate seems to be producing a sweeter pasture. The no-phosphate plot (No. 11) had a wonderful amount of grass on it, but very little clover, and the cattle neglected it. The plot that for many years had nothing put on it but phosphate (plot 12) was a well-filled-in pasture of stunted growth, but well eaten.

Two pairs of plots on the nitrogen section were very instructive. The nitrate plot had a fair sole of grass, thickening as the season advanced, but there was little clover, and the cattle avoided it. The same may be said of the old sulphate-of-ammonia plot, but it had more clover, and as a consequence was much more barely eaten than the former. In striking contrast with these two plots were the neighbouring ones that used to have their nitrogen supplied in the form of horn-dust and of dried blood. They had a fine thriving appearance, and were evidently great favourites with the stock, especially the dried-blood plot, which, except in one or two patches, was eaten quite to the ground. These two plots were not very prolific when cut for hay, although they yielded better than the bone-meal plots; but their buried residues are now becoming available, and they are next favourites to the bone-meal plots, now that the field is being pastured. The next plot (No. 17) that has not had any nitrogenous manure applied to it was fairly well covered, especially with clover, and was better and better eaten as the season advanced.

The ruinous practice of over-dosing with nitrate without other manures was well shown on plot 18, which grew very little grass, almost no clover, and was not touched by cattle till far on in the season.

Among the potash plots the first two (19 and 20) were, as usual, very much on a level, and the level was rather a low one;

but plots 21 and 22 presented a wonderful contrast. Plot 21, that had been starved of potash although liberally supplied with superphosphate and nitrate of soda annually, had a fair amount of grass but no clover, and the stock would have nothing to do with it; while plot 22, that for all these years had nothing but potash salts put on it, and had been the most miserable plot on the station, was a perfect picture of health, one mass of clover, and exceedingly well eaten down. The Peruvian and Ichaboe guano plots were fairly good; but the most surprising of the section, and indeed the most remarkable plot on the field, was plot 24, that used to be manured with fish guano. It surpassed the bone-meal plots and all the rest in its fine green, fresh appearance. It was closely grown in with both grass and clover beautifully mixed together, and was eaten as barely as if it had been cut with a lawn-mower; and indeed it looked more like a lawn than a pasture. The freshness and greenness of this plot, and in a less degree the bone-meal and dried-blood plots, marked them out among all the rest when seen from Midcalder Station, upwards of two miles away.

The superphosphate plots presented no special feature. They resembled their fellows 13 and 19, which had been similarly manured.

Plots 31 and 32, that received nitrate of soda, and plots 33 and 34, that were similarly manured, but with sulphate of ammonia in small, middling, and large doses, were also very instructive. The larger the dose of soluble nitrogenous manure, the coarser the grass and the less the clover. The stock ate it very imperfectly, and that only towards the latter part of the summer when the grass was becoming scarce on the better parts of the field.

The heavily nitrated and sulphated parts grew very patchy, tufty grass of a coarse kind, leaving bare spots between where clover might have grown, but where it had been either killed out or crushed out. A very noticeable plot was No. 38, which in former years had been heavily manured with gypsum. It was well grown with grass and also with clover, and was evidently a favourite with the stock.

The foregoing report refers to those plots in the field which had been regularly manured year after year in the manner indicated, but to which no manures were applied in 1894, when the field was being grazed.

*Manured Section.*

During 1893 and 1894 a considerable number of experiments were in progress in various parts of the country to show how

pasture could be improved by the application of lime, gypsum, kainit, slag, and green vitriol, both singly and in combination, and it was resolved to utilise a part of the station also for that purpose.

A section of the field that had not been manured for many years, but which had been annually cut for hay, was selected and divided into twenty plots, each the twenty-fourth of an acre. The manures were applied at the following rates per acre: lime, 3 tons; gypsum, 6 cwt.; slag, 6 cwt.; green vitriol, 1 cwt.; kainit, 8 cwt.; and nitrate of soda, 1 cwt. It was late before the experiment was sanctioned, and the manures were not applied till the 23d March. The method of determining the effect of the manures was the same as that described above, and it was done on three occasions. It will be sufficient to give the average results, as they did not vary much; but it was noticed that plots that had been somewhat neglected by the stock during July and August were better eaten in September, as the grass became scarcer. The average values assigned to various plots are given on Table V., and the following conclusions may be drawn from them:—

TABLE V.—Average Percentage Values of Manured Plots.

| | No. | Grass. | Clover. | Eaten. | General Average. |
|---|---|---|---|---|---|
| With gypsum— | | | | | |
| Slag | 1 | 53 | 55 | 43 | 50 |
| Slag and green vitriol | 2 | 62 | 63 | 70 | 65 |
| Slag, green vitriol, and nitrate | 3 | 60 | 38 | 47 | 38 |
| Slag and nitrate | 4 | 55 | 43 | 43 | 37 |
| With lime— | | | | | |
| Slag | 5 | 67 | 52 | 62 | 60 |
| Slag and green vitriol | 6 | 63 | 30 | 42 | 43 |
| Slag, green vitriol, and nitrate | 7 | 50 | 25 | 25 | 33 |
| With gypsum and kainit— | | | | | |
| Slag | 8 | 65 | 80 | 93 | 80 |
| Slag and green vitriol | 9 | 55 | 75 | 85 | 72 |
| Slag, green vitriol, and nitrate | 10 | 62 | 68 | 55 | 62 |
| Slag and nitrate | 11 | 57 | 70 | 72 | 66 |
| With lime and kainit— | | | | | |
| Slag | 12 | 67 | 67 | 70 | 68 |
| Slag and green vitriol | 13 | 62 | 57 | 60 | 60 |
| Slag, green vitriol, and nitrate | 14 | 65 | 50 | 37 | 51 |
| Lime alone | 15 | 53 | 37 | 43 | 44 |
| Lime and kainit | 16 | 62 | 67 | 80 | 70 |
| Kainit alone | 17 | 57 | 77 | 83 | 72 |
| Unmanured | 18 | 58 | 43 | 37 | 46 |

Gypsum did better than lime, but in the circumstances that is not to be wondered at. A heavy dose of lime in March has its drawbacks. It is too late in the season to apply it. Its effect was to retard the growth, and also to keep the stock off the plots. The grass did not suffer so much from it as the clover. The effect of the kainit was very marked. It caused a great increase of clover, with the result that that section was far more barely eaten than the other. There was a much more healthy colour on that section, due to the vigour of the grass as well as to the abundance of clover. I think it probable that the valuation of the grasses proper on the kainit section is on the low side, for, owing to its being so closely eaten, it looked less abundant than it was in reality. The object of applying green vitriol—that is to say, ferrous sulphate, or copperas as it is sometimes called—was mainly to observe its effect on clover. When applied along with gypsum and slag, either with or without kainit, its effect was very beneficial. Not only was the clover increased in quantity, but it was also well eaten down. A very characteristic action of green vitriol is its withering effect on those mosses which creep through the grass and fog up a pasture. These have very little hold of the soil and are easily destroyed by green vitriol. There were no such mosses on the station. On bare spots here and there were noticed some of the closely-growing mosses and some algæ, but the green vitriol did not seem to have affected them. Where lime was applied the addition of green vitriol did harm rather than good.

The least-expected result noticed was that on the plots where, in addition to the other substances, nitrate of soda was applied. It was not put on till the end of April, but its effect was injurious rather than otherwise. It diminished the amount of clover in most cases very considerably, but it was on the plots that had received green vitriol that its injurious effect was most marked. The effect of nitrate in diminishing or preventing the growth of clover is well known; but it is only when applied in large doses that this result is very noticeable. In this case the quantity was not such as to do injury to clover, and it was evidently not the nitrate alone that did harm, as shown on plot 11. It was the combination of green vitriol and nitrate, even although the nitrate was applied fully a month after the green vitriol. If we may trust the indications here given, it does not do to apply both nitrate and green vitriol in the same season.

TABLE I.—Percentage Values indicating the Abundance of the Grasses proper, 1894.

| No. of Plot. | Manures formerly applied. | June. | Aug. | Sept. | Average. |
|---|---|---|---|---|---|
| | *Phosphatic Manures.* | | | | |
| | With nitrate of soda and potash salts— | | | | |
| 5 | Bone-meal | 60 | 70 | 70 | 67 |
| 6 | Do. dissolved | 70 | 60 | 75 | 68 |
| 7 | Steamed bone-flour | 60 | 60 | 70 | 63 |
| 8 | Thomas-slag | 50 | 70 | 55 | 58 |
| 9 | Ground mineral phosphates | 60 | 70 | 80 | 70 |
| 10 | Superphosphate | 40 | 80 | 60 | 60 |
| 11 | No phosphates | 20 | 50 | 70 | 47 |
| 12 | Superphosphate alone | 20 | 45 | 65 | 44 |
| | *Nitrogenous Manures.* | | | | |
| | With superphosphate and potash salts— | | | | |
| 13 | Nitrate of soda | 40 | 50 | 70 | 53 |
| 14 | Sulphate of ammonia | 40 | 60 | 65 | 55 |
| 15 | Horn-dust (shoddy 1878) | 40 | 60 | 50 | 50 |
| 16 | Dried blood | 60 | 50 | 70 | 60 |
| 17 | No nitrogen | 40 | 55 | 50 | 47 |
| 18 | Nitrate of soda alone | 30 | 60 | 60 | 50 |
| | *Potassic Manures.* | | | | |
| | With superphosphate and nitrate of soda— | | | | |
| 19 | Sulphate of potash | 40 | 65 | 60 | 55 |
| 20 | Muriate of potash | 60 | 50 | 60 | 57 |
| 21 | No potash | 20 | 45 | 60 | 42 |
| 22 | Potash salts alone | 50 | 60 | 40 | 50 |
| | *Guanos.* | | | | |
| 23 | Peruvian | 70 | 67 | 50 | 62 |
| 24 | Fish | 70 | 70 | 70 | 70 |
| 25 | Ichaboe | 60 | 60 | 60 | 60 |
| 27 | Unmanured continuously | 30 | 30 | 40 | 33 |
| | *Superphosphates.* | | | | |
| | With sulphate of ammonia and potash salts— | | | | |
| 28 | 10 per cent soluble phosphate | 40 | 50 | 65 | 52 |
| 29 | 25 do. do. | 60 | 50 | 60 | 57 |
| 30 | 40 do. do. | 50 | 60 | 60 | 58 |
| | With superphosphate and potash salts— | | | | |
| 31, 32 | Nitrate of soda— | | | | |
| *a* | 144 lb. per acre | 30 | 55 | 50 | 43 |
| *b* | 288 do. do. | 27 | 55 | 55 | 46 |
| *c* | 432 do. do. | 35 | 45 | 50 | 43 |
| 33, 34 | Sulphate of ammonia— | | | | |
| *a* | 120 lb. per acre | 30 | 40 | 37 | 36 |
| *b* | 240 do. do. | 20 | 37 | 43 | 33 |
| *c* | 360 do. do. | 30 | 42 | 52 | 41 |

TABLE II.—PERCENTAGE VALUES INDICATING THE ABUNDANCE OF CLOVER, 1894.

| No. of Plot. | MANURES FORMERLY APPLIED. | June. | Aug. | Sept. | Average. |
|---|---|---|---|---|---|
| | *Phosphatic Manures.* | | | | |
| | With nitrate of soda and potash salts— | | | | |
| 5 | Bone-meal | 60 | 80 | 90 | 77 |
| 6 | Do. dissolved | 70 | 70 | 80 | 73 |
| 7 | Steamed bone-flour | 50 | 60 | 75 | 62 |
| 8 | Thomas-slag | 50 | 50 | 55 | 52 |
| 9 | Ground mineral phosphates | 20 | 30 | 30 | 27 |
| 10 | Superphosphate | 20 | 40 | 20 | 27 |
| 11 | No phosphates | 10 | 30 | 30 | 23 |
| 12 | Superphosphate alone | 40 | 60 | 50 | 50 |
| | *Nitrogenous Manures.* | | | | |
| | With superphosphate and potash salts— | | | | |
| 13 | Nitrate of soda | 40 | 50 | 35 | 42 |
| 14 | Sulphate of ammonia | 30 | 70 | 50 | 50 |
| 15 | Horn-dust (shoddy 1878) | 50 | 60 | 60 | 57 |
| 16 | Dried blood | 50 | 70 | 70 | 63 |
| 17 | No nitrogen | 30 | 70 | 80 | 60 |
| 18 | Nitrate of soda alone | 0 | 10 | 20 | 10 |
| | *Potassic Manures.* | | | | |
| | With superphosphate and nitrate of soda— | | | | |
| 19 | Sulphate of potash | 30 | 40 | 30 | 33 |
| 20 | Muriate of potash | 20 | 35 | 30 | 28 |
| 21 | No potash | 0 | 0 | 10 | 3 |
| 22 | Potash salts alone | 90 | 85 | 95 | 90 |
| | *Guanos.* | | | | |
| 23 | Peruvian | 50 | 70 | 70 | 63 |
| 24 | Fish | 70 | 70 | 70 | 70 |
| 25 | Ichaboe | 40 | 60 | 60 | 53 |
| 27 | Unmanured continuously | 20 | 40 | 40 | 37 |
| | *Superphosphates* | | | | |
| | With sulphate of ammonia and potash salts— | | | | |
| 28 | 10 per cent soluble phosphate | 40 | 35 | 40 | 38 |
| 29 | 25 do. do. | 40 | 60 | 40 | 47 |
| 30 | 40 do. do. | 40 | 50 | 40 | 43 |
| | With superphosphate and potash salts— | | | | |
| 31, 32 | Nitrate of soda— | | | | |
| *a* | 144 lb. per acre | 12 | 35 | 37 | 28 |
| *b* | 288 do. do. | 7 | 25 | 23 | 18 |
| *c* | 432 do. do. | 0 | 5 | 7 | 4 |
| 33, 34 | Sulphate of ammonia— | | | | |
| *a* | 120 lb. per acre | 17 | 22 | 35 | 25 |
| *b* | 240 do. do. | 7 | 22 | 20 | 16 |
| *c* | 360 do. do. | 5 | 7 | 15 | 9 |

TABLE III.—PERCENTAGE VALUES INDICATING THE EXTENT TO WHICH THE GRASS HAD BEEN EATEN, 1894.

| No. of Plot. | MANURES FORMERLY APPLIED. | June. | Aug. | Sept. | Average. |
|---|---|---|---|---|---|
| | *Phosphatic Manures.* | | | | |
| | With nitrogen and potash— | | | | |
| 5 | Bone-meal | 60 | 70 | 100 | 77 |
| 6 | Dissolved bones | 70 | 60 | 100 | 77 |
| 7 | Steamed bone-flour | 60 | 50 | 65 | 58 |
| 8 | Thomas-slag | 50 | 40 | 45 | 45 |
| 9 | Ground mineral phosphates | 20 | 15 | 30 | 22 |
| 10 | Superphosphate | 25 | 10 | 10 | 15 |
| 11 | No phosphate | 10 | 15 | 30 | 18 |
| 12 | Superphosphate alone | 50 | 80 | 65 | 65 |
| | *Nitrogenous Manures.* | | | | |
| | With phosphate and potash— | | | | |
| 13 | Nitrate of soda | 20 | 30 | 30 | 27 |
| 14 | Sulphate of ammonia | 30 | 60 | 50 | 47 |
| 15 | Horn-dust | 60 | 80 | 80 | 73 |
| 16 | Dried blood | 80 | 80 | 80 | 80 |
| 17 | No nitrogen | 50 | 80 | 85 | 70 |
| 18 | Nitrate of soda alone | 5 | 10 | 40 | 18 |
| | *Potassic Manures.* | | | | |
| | With nitrogen and phosphate— | | | | |
| 19 | Sulphate of potash | 35 | 30 | 30 | 32 |
| 20 | Muriate of potash | 20 | 40 | 30 | 30 |
| 21 | No potash | 10 | 0 | 20 | 10 |
| 22 | Potash salts alone | 70 | 85 | 80 | 78 |
| | *Guanos.* | | | | |
| 23 | Peruvian (with ammonia) | 50 | 70 | 70 | 63 |
| 24 | Fish | 90 | 100 | 100 | 97 |
| 25 | Ichaboe | 50 | 60 | 60 | 57 |
| 27 | Unmanured continuously | 40 | 40 | 55 | 45 |
| | *Superphosphates.* | | | | |
| | With nitrogen and potash— | | | | |
| 28 | 27 per cent soluble phosphate | 40 | 30 | 45 | 37 |
| 30 | 36 do. do. | 30 | 30 | 35 | 32 |
| 29 | Unmanured since 1889 | 40 | 50 | 40 | 43 |
| | With superphosphate and potash salts— | | | | |
| 31, 32 | Nitrate of soda— | | | | |
| *a* | 144 lb. per acre | 15 | 40 | 55 | 37 |
| *b* | 288 do. do. | 5 | 30 | 50 | 28 |
| *c* | 432 do. do. | 10 | 20 | 48 | 26 |
| 33, 34 | Sulphate of ammonia— | | | | |
| *a* | 120 lb. per acre | 25 | 25 | 52 | 37 |
| *b* | 240 do. do. | 20 | 22 | 40 | 27 |
| *c* | 360 do. do. | 0 | 20 | 42 | 21 |

TABLE IV.—SUMMARY OF OBSERVATIONS OF PASTURED GRASS, PUMPHERSTON, 1894.

| No. of Plot. | MANURES FORMERLY APPLIED. | Grass. | Clover. | Eaten. | Average. |
|---|---|---|---|---|---|
| | *Phosphatic Manures.* | | | | |
| | With nitrogen and potash— | | | | |
| 5 | Bone-meal | 69 | 77 | 77 | 74 |
| 6 | Dissolved bones | 68 | 73 | 77 | 73 |
| 7 | Steamed bone-flour | 53 | 62 | 58 | 58 |
| 8 | Thomas-slag | 58 | 52 | 45 | 52 |
| 9 | Ground mineral phosphates | 70 | 27 | 22 | 40 |
| 10 | Superphosphate | 60 | 27 | 15 | 34 |
| 11 | No phosphate | 47 | 23 | 18 | 29 |
| 12 | Superphosphate alone | 44 | 50 | 65 | 53 |
| | *Nitrogenous Manures.* | | | | |
| | With phosphate and potash— | | | | |
| 13 | Nitrate of soda | 53 | 42 | 27 | 41 |
| 14 | Sulphate of ammonia | 55 | 50 | 47 | 51 |
| 15 | Horn-dust | 50 | 57 | 73 | 60 |
| 16 | Dried blood | 60 | 63 | 80 | 68 |
| 17 | No nitrogen | 47 | 60 | 70 | 59 |
| 18 | Nitrate of soda alone | 50 | 10 | 18 | 26 |
| | *Potassic Manures.* | | | | |
| | With nitrogen and phosphate— | | | | |
| 19 | Sulphate of potash | 55 | 33 | 32 | 39 |
| 20 | Muriate of potash | 57 | 28 | 30 | 38 |
| 21 | No potash | 42 | 3 | 10 | 19 |
| 22 | Potash salts alone | 50 | 90 | 78 | 73 |
| | *Guanos.* | | | | |
| 23 | Peruvian (with ammonia) | 62 | 63 | 69 | 65 |
| 24 | Fish | 70 | 73 | 97 | 80 |
| 25 | Ichaboe | 60 | 53 | 57 | 57 |
| 27 | Unmanured continuously | 33 | 37 | 45 | 38 |
| | *Superphosphates.* | | | | |
| | With nitrogen and potash— | | | | |
| 28 | 27 per cent soluble phosphate | 52 | 38 | 37 | 42 |
| 30 | 36 do. do. | 57 | 47 | 32 | 45 |
| 29 | Unmanured since 1889 | 57 | 43 | 43 | 48 |
| | With superphosphate and potash salts— | | | | |
| 31, 32 | Nitrate of soda— | | | | |
| *a* | 144 lb. per acre | 45 | 28 | 37 | 36 |
| *b* | 288 do. do. | 46 | 18 | 28 | 31 |
| *c* | 432 do. do. | 45 | 4 | 26 | 24 |
| 33, 34 | Sulphate of ammonia— | | | | |
| *a* | 120 lb. per acre | 36 | 25 | 37 | 33 |
| *b* | 240 do. do. | 33 | 16 | 27 | 26 |
| *c* | 360 do. do. | 41 | 9 | 21 | 24 |

# FEEDING EXPERIMENT TO DETERMINE THE RELATIVE VALUE OF LINSEED-CAKE AND DRIED DISTILLERY GRAINS AS A BY-FODDER FOR SHEEP.

The experiment was undertaken by Mr Adam Logan, Ferney Castle, Reston, Berwickshire, who conducted a similar experiment in 1893, the details of which are reported in the former volume of the 'Transactions.'

Two lots of ten sheep each were selected by Mr Logan from his own home-bred stock, folded in the open field under exactly similar conditions, and fed upon an exactly equal amount of Fosterton hybrid turnips. The one lot received in addition 1 lb. per head per day of the North British Distillery Company's dried grains, and the other received in addition 1 lb. per head per day of Harburg linseed-cake.

The turnips and feeding-stuffs had the following compositions:—

| | Fosterton Hybrid. | | Dried Grains. | Linseed-cake. |
|---|---|---|---|---|
| | Fresh. | Dried. | | |
| | per cent. | per cent. | per cent. | per cent. |
| Water | 91.40 | ... | 12.22 | 14.32 |
| Albumen | .43 | 5.03 | 27.12 | 27.12 |
| Amides | .34 | 3.94 | ... | ... |
| Oil | ... | ... | 10.48 | 9.00 |
| Carbohydrates, &c. | 6.45 | 74.96 | 39.26 | 36.11 |
| Fibre | .82 | 9.60 | 8.32 | 6.82 |
| Ash | .56 | 6.47 | 2.60 | 6.65 |

The experiment began on 1st January 1895, and terminated on 4th March.

The two lots were weighed at the beginning, in the middle, and at the end of the experiment, with the results shown in Table I. (p. 434).

The total increase in weight of the two lots was thus 15 stones 7 lb. and 15 stones 8 lb. respectively; or, in other words, the two lots made exactly equal progress as regards increase of live-weight.

The object in view in taking so many as ten sheep was to enable us to eliminate any errors due to accidental circumstances, such as the occurrence of illness in any of the animals, or the more common accident of having among the number some individual that, without exhibiting any specific ailment,

happened to be not thriving and off its feed; or, on the other hand, any individual who might be a great feeder and make so much progress as to disturb the general result.

TABLE I.

| No. | Dried Grains. | | | | | | No. | Linseed-cake. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. 1. | | Feb. 12. | | March 4. | | | Jan. 1. | | Feb. 12. | | March 4. | |
| | stones | lb. | stones | lb. | stones | lb. | | stones | lb. | stones | lb. | stones | lb. |
| 1 | 8 | 11 | 9 | 12 | 10 | 8 | 1 | 8 | 4 | 9 | 2 | 9 | 11 |
| 2 | 8 | 7 | 9 | 0 | 9 | 2 | 2 | 8 | 9 | 9 | 13 | 11 | 1 |
| 3 | 7 | 7 | 8 | 7 | 9 | 3 | 3 | 8 | 9 | 9 | 3 | 9 | 13 |
| 4 | 8 | 7 | 9 | 4 | 9 | 13 | 4 | 7 | 10 | 8 | 6 | 9 | 2 |
| 5 | 7 | 1 | 8 | 0 | 8 | 6 | 5 | 8 | 0 | 8 | 11 | 9 | 5 |
| 6 | 8 | 4 | 9 | 4 | 9 | 9 | 6 | 7 | 10 | 8 | 4 | 8 | 12 |
| 7 | 7 | 11 | 9 | 1 | 9 | 8 | 7 | 7 | 3 | 8 | 5 | 9 | 1 |
| 8 | 7 | 9 | 8 | 10 | 9 | 5 | 8 | 7 | 10 | 8 | 10 | 9 | 1 |
| 9 | 8 | 2 | 9 | 7 | 10 | 2 | 9 | 7 | 11 | 8 | 12 | 9 | 7 |
| 10 | 7 | 3 | 8 | 4 | 8 | 13 | 10 | 7 | 13 | 8 | 6 | 9 | 6 |
| Total | 79 | 6 | 89 | 7 | 94 | 13 | Total | 79 | 9 | 88 | 2 | 95 | 3 |
| | | | | | 79 | 6 | | | | | | 79 | 9 |
| | | | Total increase | | 15 | 7 | | | | Total increase | | 15 | 8 |

An examination of the figures in Table I. shows the following increase per head of the two lots:—

Increase per Head.

| | Dried grains stones. | lb. | Linseed cake. stones. | lb. |
|---|---|---|---|---|
| 1. . . . | 1 | 11 | 1 | 7 |
| 2. . . . | 0 | 9 | 2 | 6 |
| 3. . . . | 1 | 10 | 1 | 4 |
| 4. . . | 1 | 6 | 1 | 6 |
| 5. . | 1 | 5 | 1 | 5 |
| 6. . . . | 1 | 5 | 1 | 2 |
| 7. . . | 1 | 11 | 1 | 12 |
| 8. . . . | 1 | 10 | 1 | 5 |
| 9. . . | 2 | 0 | 1 | 10 |
| 10. . . | 1 | 10 | 1 | 7 |
| | 15 | 7 | 15 | 8 |

The total increase per head in each of the two lots is 1 stone 7 lb.; but it is evident that in the case of sheep No. 2 in each lot their increase is abnormal—the one has been off his feed and the other has been a huge feeder, and in order to make a fair comparison between the two lots these two individuals should be withdrawn. If that were done the total increase in live-weight of the two lots would be—

| | st. | lb. |
|---|---|---|
| Fed with grains . . . . . . . | 14 | 12 |
| Fed with linseed-cake . . . . . . . | 13 | 2 |
| Difference . . | 1 | 10 |

This would represent an increase of $2\frac{2}{5}$ lb. per head of the grain-fed lot over those fed on linseed-cake.

At the close of the experiment the sheep were fat and sent to the butcher, who weighed the carcass and tallow of each animal, and the weights were as follows:—

| No. | Dried Grains Lot | | | No. | Linseed-cake Lot. | | |
|---|---|---|---|---|---|---|---|
| | Carcass. | Tallow. | Total. | | Carcass. | Tallow. | Total. |
| | lb. | lb. | lb. | | lb. | lb. | lb. |
| 1 | 76 | 9 | 85 | 1 | 70 | 7 | 77 |
| 2 | 70 | 9 | 79 | 2 | 80 | 6½ | 86½ |
| 3 | 66 | 7 | 73 | 3 | 68 | 8 | 76 |
| 4 | 66 | 6½ | 72½ | 4 | 64 | 7½ | 71½ |
| 5 | 62 | 5½ | 67½ | 5 | 65 | 5½ | 70½ |
| 6 | 66 | 7½ | 73½ | 6 | 66 | 8 | 74 |
| 7 | 73 | 7 | 80 | 7 | 64 | 6 | 70 |
| 8 | 71 | 7½ | 78½ | 8 | 68 | 6 | 74 |
| 9 | 74 | 7 | 81 | 9 | 69 | 7½ | 76½ |
| 10 | 60 | 6½ | 66½ | 10 | 66 | 5½ | 71½ |
| Total | 684 | 72½ | 756½ | Total | 680 | 67½ | 747½ |
| | | Deduct No. 2 | 79 | | | Deduct No 2 | 86½ |
| | | | 677½ | | | | 661 |

Even without withdrawing No. 2 from each lot the grain-fed lot weigh more in carcass than the others; but on withdrawing these the difference in favour of the grain-fed lot is 16½ lb., or 1.8 lb. per head for the 62 days during which the experiment lasted.

The grain-fed lot made most progress during the first month, and the cake-fed lot did best during the second. It is probable that if the experiment had lasted another month the cake-fed lot would have made up on the others.

The linseed-cake cost £7, 15s. per ton, and the grains £4, 5s. per ton, delivered; so that for the two months during which the experiment lasted the cost of the cake was 41s. 2d., and that of the grains 24s. 10d., or about 4s. 1d. and 2s. 6d. per head of the cake- and grain-fed lots respectively.

# MANURIAL EXPERIMENTS IN VARIOUS PARTS OF SCOTLAND.

## THE ECONOMICAL MANURING OF THE TURNIP CROP, BEING THE RESULT OF FIELD EXPERIMENTS IN BANFFSHIRE IN 1894.

### EXPERIMENT VIII. C.

The success which attended the application of this test on forty different farms in the four districts of Banffshire in 1893 was so great, and the lessons taught by it so useful, that a request was made to the Society by the local associations to have the experiment repeated under the altered conditions of another season. It was considered that the severe drought of 1893 was unfavourable to the action of light manures generally, and particularly to the less soluble of them, so that another season might be able to yield fresh information. A very large number of farmers undertook the work in five districts, each under the charge of a local secretary. Most of them laid down the experiment in two ways: one set of manures was put upon land to which no dung was applied, and another set of a similar kind, but in half quantity, was applied along with dung.

The following were the manures applied, the quantity, and the cost per acre:—

| Plot. | Quantities of Manure. | Per plot lb | Per plot oz | Per acre cwt. | Cost per acre. s. | Cost per acre. d. |
|---|---|---|---|---|---|---|
| 1. | Fine bone-meal | 11 | 3 | 4 | =26 | 0 |
| | Nitrate of soda | 0 | 11 | ¼ | | |
| 2. | Superphosphate | 16 | 12 | 6 | =26 | 0 |
| | Nitrate of soda | 2 | 13 | 1 | | |
| 3. | Thomas-slag | 25 | 0 | 9 | =26 | 0 |
| | Nitrate of soda | 2 | 13 | 1 | | |
| 4. | Mixed super and slag | 21 | 0 | 7½ | =26 | 0 |
| | Nitrate of soda | 2 | 13 | 1 | | |
| 5. | Mixed super and slag | 21 | 0 | 7½ | =35 | 0 |
| | Nitrate of soda | 5 | 10 | 2 | | |
| 6. | Fine bone-meal | 11 | 3 | 4 | =26 | 0 |
| | Sulphate of ammonia | 0 | 9 | ⅕ | | |
| 7. | Superphosphate | 16 | 12 | 6 | =26 | 0 |
| | Sulphate of ammonia | 2 | 4 | ⅘ | | |
| 8. | Mixed super and slag | 21 | 0 | 7½ | =17 | 0 |
| 9. | Nothing | ... | | ... | ... | |

There were in all seventy-eight experiments laid down by the Banffshire farmers—forty-one without dung in the quantities per acre given in the table, and thirty-seven along with dung, but in only half the quantities given in the table. The pre-

vious season no difference was made in the quantities of manure applied, whether with or without dung; but it was found that the increase got by applying so large a dose of fertilisers along with dung did not pay the cost of the manure, although when applied alone it paid very well. Accordingly it was resolved to put on only half the quantity of fertilisers to the dunged plots this season.

Before discussing the results and comparing them with those of 1893, it is necessary to consider the character of the season and the circumstances of the crop. In 1893 the chief obstacle to the production of a heavy turnip crop was drought, in 1894 it was rain, or I should rather say floods.

In the first half of July there were six consecutive days during which 4½ inches of rain fell, and on one of these the rainfall was 1.60 inches. Very few of the experiments had been singled by that time, and many of the fields where they were lying were flooded, and some so badly that the braird was entirely submerged. On this account, and on account of the widespread occurrence of finger-and-toe among the weakened plants, a large proportion of the experiments were so utterly ruined that it was found unnecessary to weigh the crops, and they were simply reported as failures. In other cases the crops which had been put down with so much care were weighed, if for no other purpose than to show the havoc that had been wrought. The net result is, that out of the seventy-eight experiments only thirty-eight are fit to be recorded, and in some of these the crop is so small that it would not be fair to the farmers to publish the results.

I have therefore thought it expedient to refrain from publishing the individual cases, and to content myself with summarising the results of each district, with the exception of the Enzie district, where the floods were so great and the ruin so complete, that there were not a sufficient number of reliable results to enable a summary to be made.

It will be seen from the table (p. 438) that the crops all over were small—about 18 tons per acre, or about 2 tons less than in the former year of drought.

On the undunged section, the plot that got no manure of any kind (No. 9) produced on an average 10 tons 16 cwt. per acre of bulbs. The application of phosphates (mixed superphosphate and slag, plot 8) at a cost of 17s. per acre produced an increase of about 6 tons per acre. That is the most profitable plot of all. It was so the former season also, when for 17s. worth of phosphate an increase of 8 tons per acre was obtained. The further addition of nitrate of soda or sulphate of ammonia, at a cost of 10s. per acre (plots 2, 4, and 7), increased the crop by nearly 2 tons per acre. The addition of double that quantity

TABLE I.—Summary of Results of Experiments on Manuring Turnips in Banffshire, 1894.

*Without Dung.*

| No. of plot . . . . | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | 9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manures . . | Bone-meal and nitrate | | Superphosphate and nitrate | | Slag and nitrate | | Mixed super and slag and nitrate | | Mixed super and slag and double nitrate | | Bone-meal and ammonium sulphate | | Superphos. and ammonium sulphate | | Mixed super and slag | | Nothing | |
| | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. |
| Central district . . | 14 | 3 | 16 | 1 | 16 | 11 | 15 | 8 | 18 | 12 | 16 | 17 | 16 | 15 | 15 | 3 | 10 | 10 |
| Cullen " . | 19 | 11 | 23 | 5 | 21 | 10 | 23 | 2 | 24 | 1 | 20 | 12 | 23 | 17 | 21 | 8 | 12 | 14 |
| Banff " . . | 18 | 2 | 19 | 14 | 20 | 13 | 20 | 12 | 22 | 5 | 21 | 16 | 20 | 18 | 18 | 12 | 14 | 19 |
| Speyside " . . | 9 | 12 | 12 | 19 | 12 | 9 | 12 | 18 | 14 | 8 | 9 | 17 | 13 | 0 | 11 | 0 | 5 | 2 |
| 22 experiments, average | 15 | 7 | 18 | 0 | 17 | 16 | 18 | 0 | 19 | 16 | 17 | 5 | 18 | 13 | 16 | 11 | 10 | 16 |

*With Dung.*

| | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central district . . | 16 | 18 | 18 | 8 | 18 | 10 | 16 | 15 | 18 | 9 | 16 | 19 | 16 | 0 | 16 | 0 | 13 | 15 |
| Cullen " . . | 21 | 0 | 25 | 7 | 20 | 14 | 20 | 5 | 22 | 10 | 19 | 12 | 22 | 8 | 21 | 8 | 21 | 16 |
| Banff " . . | 21 | 5 | 21 | 12 | 21 | 6 | 20 | 4 | 21 | 19 | 19 | 5 | 20 | 9 | 20 | 12 | 18 | 10 |
| Speyside " . . | 13 | 2 | 14 | 0 | 14 | 8 | 14 | 7 | 15 | 8 | 14 | 13 | 13 | 9 | 14 | 4 | 12 | 0 |
| 16 experiments, average | 18 | 1 | 19 | 17 | 18 | 14 | 17 | 18 | 19 | 11 | 17 | 12 | 18 | 1 | 18 | 1 | 16 | 10 |

of nitrate (plot 5) raised the crop to an average of 19 tons 16 cwt., which represents an increase of about 3 tons of turnips for 20s. worth of nitrate. That is a small increase for so large an expenditure; but the wonder is that it is so great, inasmuch as, owing to the heavy rains occurring at an early part of the season, it is quite certain that a good deal of the nitrate was washed out of the land before the roots of the crop were there to prevent it. During the previous season of drought, the increase due to the additional dose of nitrate was only about 2 tons per acre. It is quite evident that only during a favourable season—neither too wet nor too dry—would it be possible to recover from the land the price of 2 cwt. of nitrate of soda per acre in the form of turnip increase. As regards the relative efficiency of the three kinds of phosphate under experiment, the answer given is very little different from that of the previous year. Superphosphate, or a mixture of superphosphate and slag, is again to the front; but slag has improved its position, and shown itself to be almost as good as superphosphate when applied in quantity representing the same money value. In this respect it corroborates former experience, which showed slag to be a phosphate well suited for wet seasons. Again, we find the bone-meal plot (No. 1) very backward; and there need be no doubt that its inferiority is due not so much, if at all, to the phosphate as to the nitrogen of the manure. The small quantity of nitrate of soda given to that plot, so as to put it on a level with the others as regards nitrogen, would doubtless be mostly washed away at the beginning of the season, and the crop would be left to depend for its nitrogen almost solely on that contained in the bones, which is of a slowly decomposing kind. Its inferiority to the other plots is, however, not quite so marked as in the preceding season of drought.

A comparison of plots 1 and 6 is instructive, as showing the superiority of sulphate of ammonia over nitrate of soda during a wet season. They are both bone-meal plots, the former receiving its extra nitrogen in the form of nitrate of soda, and the latter in the form of sulphate of ammonia. The quantity of nitrogen applied was the same in both, but there is a difference of 2 tons of turnips per acre in favour of plot 6, which got its nitrogen in the form of sulphate of ammonia.

The plot which has produced the largest crop is plot 5, to which a double dose of nitrate was applied. It no doubt suffered with the rest, but the large amount of nitrate it received prevented its being so severely drained of nitrogen as the neighbouring plots.

In a year so disastrous, it would be unwise to rely absolutely on the quantitative data provided by these experiments; but, despite the occurrence of a few individual instances of abnor-

malities, we may safely rely upon the general accuracy of the results of the twenty-two experiments recorded, and accept them as affording trustworthy indications at least of the effects produced by the manures employed. When read in the light of the special circumstances in which the crops were grown, they afford upon the whole a very satisfactory confirmation of the accuracy of the conclusions drawn from the previous year's experience.

There remains only a few words to be said regarding the second department of this inquiry—viz., the effects produced by the manures upon the crops to which a liberal supply of dung had been applied. Keeping in mind that only half the amounts of fertilisers were put upon this section, we find, as we should expect to find, that the differences between the various plots are much less marked; but it is a proof of the general reliability of the experiments that such indications as are presented confirm the accuracy of the information supplied by the experience of the former year.

We have again brought forcibly before our notice, that dung possesses no advantage over light manures in the raising of a turnip crop. The average produce derived from the application of about 20 tons per acre of farmyard manure was 16½ tons, or about 6 tons more than was produced on the plots to which no manure of any kind had been applied, and precisely the same amount as was obtained from the plot (No. 8) which was manured with nothing but phosphate—viz., a mixture of superphosphate and slag.

We are accustomed to regard farmyard manure as a safe stand-by in exceptional seasons, whether of drought or of flood. It has the character of being well adapted to modify extremes of any kind, whether of soil or climate.

We have here an opportunity of seeing what it can do for the turnip crop in a season of flood. During the former season of drought 20 tons of dung produced an increase of about 10 tons of turnips; during the wet season it has produced an increase of only 5 tons 14 cwt. per acre. The dung has evidently suffered much—the more soluble part of it, the soluble nitrogenous matter, has evidently been washed away. The dung was applied in the drills as usual, and it is probable that in that position, lying heaped together in a loose way, it is less protected from the effect of either drought or flood than if it were intimately incorporated with the soil. It is in the intimate union of the dung with the soil that safety lies. When dung is distributed uniformly through the soil it improves its texture, and it does so on account of the large amount of organic matter it contains. The organic matter acts as a cement to light soils, giving them coherence, and enabling

them to retain better the soluble elements of fertility which they may contain. While pent up in the closed drills it has not yet had an opportunity of ameliorating the texture of the soil as a conserver of fertility. In the case of strong stiff soils, the advantage of having a loose and somewhat hollow bed immediately below the seed may be of special advantage for the immediate production of a turnip crop; but in the case of light or medium soils it is in the intimate union of the soil and the dung that are found the best conditions for conserving the elements of fertility, and for supplying them in proper measure and in due season to the roots of the crop. The heaviest crop recorded among the experiments was grown upon a field in the Cullen district, which, according to the usual practice on the farm, was dunged in the autumn, and which produced, despite the unfavourable season, not far short of 40 tons of turnips per acre.

The most notable fact exhibited by the dunged section is that the application of twenty loads of farmyard manure, even with the assistance of the half dose of artificials, has produced a crop scarcely any heavier than that upon the undunged section with a full dose of artificials. The obvious inference is that there has been a great waste of dung, and a fresh proof is thus afforded of the truth of the conclusions drawn from the results of the former year's experiments, and discussed at some length in my report, that the fallow-break is not a safe place on which to apply so valuable a commodity as farmyard manure. Had the whole of the dung, or even the half of it, been spread upon grass, a very large part of the manurial matter which has escaped by the drains would still have been in the land. If the experimenters who have carried on the work so carefully in Banffshire during the last two years have been impressed with that one lesson alone, the trouble and all the expense involved in the experiments will have been well spent.

*Experimenters.*

Banff District—

Mr George Donald, *Secretary*.
Mr A. Simpson, Duff House, Banff.
Mr L. E. Longmore, Baldaire, Boyndie.
Mr G. M. Allan, Montbletton, King Edward.
Mr J. Barclay, Cowfords, Ladysbridge.
Mr W. Livingstone, Newton Montblairy, Turriff.
Mr Fowler, Asylum, Ladysbridge.
Mr T. Pirie, Little Blairshinnoch, Ladysbridge.

Central District—

Mr George Gray, Cantlay, Grange.
Mr A. Wilson, Beiryleys.
Mr J. Leith, Glengeirick.
Mr W. Watt, Upper Forgie.

Mr J. M'Pherson, Mains of Mulben.
Mr W. F. D. Steuart, Auchlunkart.
Mr T. G. Duff, Drummuir.
Mr J. Garden, Westertown.
Mr Alexander Humphrey, Lower Towie.
Mr C. Kemp, Auchencrieve.
Mr W. M'William, Upper Woodside.

Enzie District—
Mr Alexander Smith, Bogs, *Secretary.*
Mr J. Smith, Othill.
Mr John H. Bailey, Braes.
Mr Alexander Robertson, Auchenhalrig.

Upper District—
Mr A. R. Stuart, of Inverfiddoch, *Secretary.*
Sir George Macpherson-Grant, of Ballindalloch.
Colonel Smith, Menmore.
Mr John A. Grant, Blairfindy.
Mr J. R. Findlay, Aberlour.
Mr Colin Bisset, Wester Elchies.
Mr William Craig, Easter Gauldwell.
Mr Alexander Hutcheson, Belnagarrow.
Mr John Alcock, Balvenie.

Cullen District—
Mr George Bruce, Tochieneal, *Secretary.*
Mr C. Y. Michie, Cullen.
Mr G. Milne, Dytach.
Mr A. Gunn, Kilnhillock.
Mr Alexander Kitchen, Clune.
Rev. G. M. Park, Deskford.
Mr W. M'Combie, Leitcheston.
Mr W. Fortune, Broom.
Mr William Hutcheson, Anchip.
Mr George Smith, Ordens.
Mr Robert Turner, Cairnton.

## MANURING OF BEANS.

### EXPERIMENT XVIII. (A.)

The object of this experiment was to test the utility of potash, lime, and green vitriol as ingredients in a bean manure, and to compare the results with those obtained by the application of dung in the autumn or winter. The following were the kind and quantity per acre of the manure applied to plots of one quarter acre each:—

| Plot. | | cwt. | per acre. |
|---|---|---|---|
| 1. | Kainit | 8 | cost=32s. |
| | Slag | 4 | |
| | Gypsum | 4 | |
| 2. | Muriate of potash | 2 | cost=32s. |
| | Superphosphate | 4 | |
| | Gypsum | 4 | |
| 3. | Muriate of potash | 2 | cost=35s. |
| | Superphosphate | 4 | |
| | Gypsum | 4 | |
| | Green vitriol | 1 | |
| 4. | Farmyard manure. | | |

This experiment was laid down on ten farms in Stirlingshire in 1893, and I visited most of them when the pods were well filled, but still green, on 1st August. I looked forward to having a large number of very reliable results from which safe conclusions might be drawn, but owing to a variety of circumstances accidents occurred during cutting and harvesting which destroyed the most of them so that only three completely reliable reports were received. Last year another attempt was made to have the experiment carried out in Stirlingshire and in the Carse of Gowrie district, but with even less success. A number of the experimenters cut their crops green, for, owing to the wetness of the season, they abandoned all hope of obtaining a remunerative crop of grain, and therefore utilised the crop, which went almost entirely to stem and leaf, as fodder for cattle.

The five sets of results which are given in the table (p. 444) show that as good crops can be grown with the light manures applied as with dung, and there is no marked differences noticed as due to any one kind of manure over the others. Kainit and muriate were equally effective, and green vitriol sometimes did good, sometimes did harm, and sometimes was indifferent. Upon the whole, there is nothing in this experiment to recommend the application of green vitriol as a manure for the bean crop.

*Experimenters.*

Mr Wm. Alexander, Loanside, Clackmannan.
Mr Wm. T. Malcolm, Dunmore Home Farm, Larbert.
Mr Robert Paterson, Hill of Drip, Stirling.
Mr James M'Laren, Bandeath, Stirling.
Mr Duncan M'Laren, Cornton, Stirling.
Mr R. C. Macfarlane, Greenburn, Stirling.
Mr John More, Fordhead, Kippen.
Mr Peter Dewar, King's Park, Stirling.
Mr John Drysdale, Fairfield Farming Co., Stirling.
Mr James Paterson, Burnbank, Stirling.
Mr John Prain, Mains, Castle Huntly, Longforgan.
Mr James Beveridge, Crombie, Dunfermline.
Mr Wm. B. Paton, Monorgan, Longforgan.
Mr Geo. Bell, Inchmichael, Errol.
Mr Alex. M. Prain, Rawes, Longforgan.

## EXPERIMENT XVIII. A. MANURING OF BEAN CROPS.

| Manures | | 1 Kainit. Slag. Gypsum. | | | 2 Muriate of potash. Slag. Gypsum. | | | 3 Muriate of potash. Superphosphate. Gypsum. Green vitriol. | | | 4 Farmyard manure. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Grain. | | Straw. | Grain. | | Straw. | Grain. | | Straw. | Grain. | | Straw. |
| | Year. | lb. per acre. | lb. per bushel. | cwt. per acre. | lb. per acre. | lb per bushel. | cwt. per acre. | lb. per acre. | lb. per bushel. | cwt. per acre | lb. per acre. | lb. per bushel. | cwt. per acre. |
| Hill of Drip . . . | 1893 | 2744 | 67 | 29 | 2544 | 67 | 27 | 2948 | 67 | 32 | 2812 | 67 | 28 |
| Fairfield . . . | 1893 | 2644 | 65 | 29 | 2744 | 66 | 30½ | 2732 | 64½ | 30¾ | 2590 | 64¾ | 40 |
| Dunmore . . . | 1893 | 2840 | 67 | 29 | 2660 | 67 | 28¼ | 2660 | 67 | 32¾ | 2700 | 67 | 31 |
| Mains, Castle Huntly . | 1894 | 1792 | 60 | 46 | 2016 | 61 | 49 | 1680 | 60 | 41 | 1872 | 60¼ | 45 |
| Crombie . . . | 1894 | 2728 | 64 | ... | 2771 | 64 | ... | 2735 | 64 | ... | 2944 | 64 | ... |

# MANURING OF LEA OATS.

## EXPERIMENT XXI.

The object of this experiment, which was undertaken at the request of a number of farmers in Aberdeenshire, was to test the value of muriate of potash and superphosphate as a preparation for lea oats; and further, to see if there was any advantage in applying the manures about two months before sowing rather than with the seed.

It was tried on seven farms, but on four of these the experiment was spoiled owing to the prevalence of "grub," which was a great plague in Aberdeenshire during the wet season of 1894. The harvest was so late that in the middle of October nearly half the oat crop was still uncut.

Three reports containing quantitative results have been received, but as they did not altogether escape the attack of grub, and as the number is so few, a merely general report will suffice in the meantime until another season, when under more favourable conditions and with a larger number of experiments reliable quantitative results may be obtained. The scheme of the experiment was as follows: An acre of ground was set apart and divided in two—one-half for the winter application, and the other for the spring one, and each half was divided into six plots manured thus:—

Plot.
1. No manure.
2. Superphosphate.
3. Superphosphate and sulphate of ammonia.
4. Muriate of potash alone.
5. Muriate of potash and superphosphate.
6. Muriate of potash and superphosphate, and sulphate of ammonia.

The superphosphate was applied at the rate of 2 cwt., the muriate of potash at the rate of 1 cwt., and the sulphate of ammonia at the rate of ½ cwt. per acre.

There was a very slight advantage due to the application of superphosphate, little or none from the application of muriate of potash, but a considerable increase from the sulphate of ammonia.

In some cases the winter-manured half was the best, and in others the spring-manured one; but it was noticed that the winter-manured half was less affected by grub, and in one instance (Inschfield) the whole field was destroyed by grub except on plot 6 of the winter-manured half of the experimental acre. The effect of the winter manuring in this case was so

marked that plot 6 looked as if sheep had been folded on it, but plot 6 of the spring-manured half was badly eaten. It was also noticed on this farm that plot 5 was ripe nearly a month earlier than the rest of the field.

The general result of the experiments is such as to indicate that on some soils and in some circumstances the application of superphosphate and potash may advantageously take place in winter, and that even sulphate of ammonia may be applied with advantage some weeks before sowing.

*Experimenters.*

Mr Middleton, Cushiestown, Wartle.
Mr Adam Gray, Little Pitinnan, Old Meldrum.
Mr J. K. Ledingham, Plaidy Farm, Turriff.
Mr Alex. Keith, Kinnermit, Turriff.
Mr John Milne, Mains of Laithers, Turriff.
Mr Wm Durno, Aulten, Insch.
Mr G. A. Bruce, Inschfield, Insch.

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## MANURING OF LEA OATS.

### EXPERIMENT XXII.

The object of this experiment was to discover how best to increase the quantity of the oat crop without impairing the quality of the grain or the strength of the straw.

It is well known that soluble nitrogenous manures—such as nitrate of soda or sulphate of ammonia—when applied as a sole top-dressing to the oat crop, increase the bulk of the crop, especially as regards the straw. Soluble phosphate applied in addition increases the total crop, but it is liable to lodge before it has ripened. To remedy this defect, and to maintain, or even to improve, the quality of the grain, muriate of potash and also common salt were applied in this experiment.

The manures were applied at the following rates per acre:—

| | Cwt. |
|---|---|
| Superphosphate | 3 |
| Muriate of potash | 1½ |
| Common salt | 3 |
| Nitrate of soda | 1 or 1½ |
| A mixture of nitrate of soda and sulphate of ammonia | 150 lb. |

These are larger quantities than are commonly applied, but they were intended for application to poor land where the lea-oat crop was usually deficient.

To carry out a thoroughly reliable experiment on a cereal crop is much more difficult than on a turnip crop. To do so on an agricultural scale requires that the plots should be large, and to secure an even piece of ground for the experiment requires that the plots should be small. In this instance one-eighth acre was chosen as the size of plot that would most probably strike the safe medium. The whole experiment covered an acre and a half.

Mr William Gemmill, Greendykes, Macmerry, included three other plots in his experiment to enable a contrast to be drawn between nitrate of soda and sulphate of ammonia (Table I., p. 450); and as it was at his instigation that the experiment was arranged, and as he took the greatest interest in it, carried it out with the greatest care, and sent in a report of it which is quite a model of what such reports should be, I cannot do better than record it separately and in his own words:—

"The piece of land on which the plots were arranged was as even as it could very well be, and was in poor condition, giving the experiment a very fair chance. The season, unfortunately, was rather against growing a big crop on that class of soil—heavy loam, and rather thin, with clay subsoil—but the crop got very well ripened, and was harvested and thrashed in the very best order.

"The oats were sown—4 bushels to the acre—on 21st March. The plots all brairded well, but it was not long until those which had received nothing with the seed began to show a less intense green than the others. There was not really much difference, however, till the frost of 20th and 21st May, when plots 1 and 12 and plot 7 which had only recently received its nitrate, suffered very severely. The other plots did not seem to feel the frost much, but 1 and 12 never recovered from it, or from the effects of wet weather which set in about the 28th May and continued for the greater part of the season.

"About this time (end of May) the most noteworthy point was the excellence of all those plots which had received muriate of potash (6, 8, 10, 2, and 15). No. 10 looked best at this time, and continued to do so all through. After it I thought 8, 4, 2, and 6 came in the order named. After the heavy rains of the first half of June the plots which had got their nitrate with the seed (except No. 10) fell off considerably, while those which had been top-dressed with it on the braird made great progress, especially No. 7, which about the end of June looked second-best of the 12. At no time, however, did the crop look like being a large one, as it all seemed to suffer from excess of moisture. The crop ripened well, and was cut on 31st August and thrashed on 15th September in first-rate order.

"The results of the experiment are fairly well in accordance

with what one would expect in a wet season. Nitrate on the braird has in nearly every case proved superior to that sown with the seed. The only exception is No. 10, which all along was the best of the original 12; but I am certain that even it was not so superior at the end to some of the other plots as it was at the earlier stages of its growth. This was especially noticeable in comparing it with No. 7, which at one time looked one of the worst, but which finished second-best. A very strange circumstance is the disappointing return from the nitrate and sulphate mixture, especially on plot No. 3, which never looked well. Another result which rather astonished me was the considerable increase both in straw and grain got by the addition of common salt to the manure, as is seen by comparing plots 5 and 11 with the salted plots 9 and 4."

This experiment was also carried out by Mr R. Campbell at Castlemilk Home Farm, and by Mr James Shields at his two farms of Dolphingstone, Tranent, East Lothian, and Barracks, Livingston, West Lothian, with the results shown in Table II. (p. 451).

Mr Shields' experiments were tried on two very different kinds of land. At Barracks the soil was a stiff thin clay loam in poor condition. The experimental plots were the best crop of the field, but none of them were laid. The soil at Dolphingstone, on the other hand, was a fine dark loam that had been a year in grass, and eaten with sheep fed with cotton-cake during the entire season. It was a 25-acre field, in fine condition, and yielded all over 8½ quarters per acre of oats, so that the manures were too strong for it, and all the plots were more or less laid. The order of excellence of the plots was taken on three occasions. On 10th May the order was 10, 8, 6, 3, 2; on 1st June, 10, 2, 8, 3, 11, 5; and at the finish, 2, 10, 4, 9, 6, 8.

At Castlemilk, where the field was of a thin moorish character, the crops suffered a good deal from lodging. Those which were worst laid were the plots top-dressed with nitrate of soda. The addition of muriate of potash was not effective in preventing lodging, but common salt proved effective in that respect on this as on all the other farms; and that may be regarded as the chief lesson taught by the experiment. And as it was one of the main objects in view, it is satisfactory to see that at the four farms on which it was tried a uniform result has been obtained.

The weight of the dressed grain per bushel was carefully determined at Greendykes and Castlemilk, and the results are in this respect also very concordant. The lightest grain was grown on the unmanured plots, and next to them were the plots which received the nitrate of soda as a top-dressing on the braird.

The extra plots at Greendykes which got sulphate of ammonia instead of nitrate of soda produced a lighter grain; and although the amount of grain was greater than on the other plots, the crop suffered more from lodging. This was counteracted on plot 15 by the addition of muriate of potash; and it is probable that a plot manured with sulphate of ammonia and common salt would have succeeded even better than the others, but that was not included in the experiment.

*Experimenters.*

Mr Wm. Gemmill, Greendykes, Macmerry.
Mr R. Campbell, Castlemilk Home Farm, Lockerbie.
Mr James Shields, Dolphingstone, Tranent.

[Tables

TABLE I.—EXPERIMENT XXII. MANURING LEA OATS A[illegible]

| Plot. | Manures. | Dressed grain. | cwt. per bushel. | Light grain. | Straw. |
|---|---|---|---|---|---|
| | | lb. | lb. | lb. | lb. |
| 1 | Nothing . . . . . . . | 194 | 43½ | 7 | 280 |
| 12 | Nothing . . . . . . . | 193 | 43¼ | 8 | 252 |
| 7 | Nitrate of soda on braird . . . | 283½ | 43¾ | 10 | 476 |
| 5 | Nitrate of soda and super . . . | 264½ | 44⅛ | 7 | 378 |
| 11 | Nitrate of soda on braird . . . | 262 | 43¾ | 9 | 448 |
| 3 | Nitrate of soda, sulphate of ammonia, and super | 245 | 43⅝ | 6 | 392 |
| 9 | Nitrate of soda, super, and salt . | 274 | 44 | 6 | 448 |
| 4 | Nitrate of soda on braird, super, and salt | 282 | 44 | 6 | 476 |
| 6 | Nitrate of soda on braird, super, and muriate | 256 | 43¾ | 6 | 392 |
| 8 | Nitrate of soda, sulphate of ammonia, super, and muriate | 278 | 44¼ | 7 | 476 |
| 10 | 1½ nitrate of soda, super, and muriate | 284 | 44 | 9 | 490 |
| 2 | 1½ nitrate of soda on braird, super and muriate | 276 | 44 | 6 | 476 |
| 13 | 1⅛ sulphate of ammonia . . . | 290 | 43¼ | 6 | 532 |
| 14 | 1⅛ sulphate of ammonia and super . | 291½ | 43⅜ | 10 | 504 |
| 15 | 1⅛ sulphate of ammonia, super, and muriate | 280 | 43½ | 6 | 490 |

TABLE II.—EXPERIMENT XXII. MANURING OF

*Dressed Grain.*

| No. of plot . . . | 1 and 12 | 7 | 5 | 11 | 3 |
|---|---|---|---|---|---|
| Manures . . | Nothing. | Nitrate on braird. | Nitrate. Super. | Nitrate on braird. Super. | Nitrate and sulphate. Super. |
| Castlemilk . . . | 180 | 148 [1] | 205 [2] | 204 | 206 [2] |
| Dolphingstone . . | 335 | 331 | 358 | 331 | 318 |
| Barracks . . . | 127 | 152 | 133½ | 108 | 163½ |

*Straw.*

| | | | | | |
|---|---|---|---|---|---|
| Castlemilk . . . | 240 | 305 | 414 | 445 | 541 |
| Dolphingstone . . | 644 | 560 | 644 | 672 | 728 |
| Barracks . . . | 364 | 392 | 364 | 504 | 448 |

[1] Much lodged.

GREENDYKES, MACMERRY. PER ⅛ ACRE.

| Remarks. |
|---|
| Very poor crop all along; suffered severely from frost on 20th May. |
| Very poor; this and No. 1 greenest when cut. |
| Did better than any of the others after it got the nitrate; slightly laid. |
| Disappointing; poorest of manured plots. |
| Very fair; improved immensely after getting nitrate. |
| Rather disappointing. |
| Looked middling all along; threshed better than its appearance indicated. |
| Fine crops and all standing. |
| The plot had not a fair chance; a strip of 3 feet broad brairded badly, and it was only half the thickness of the rest. |
| Looked well at first; fell off latterly. |
| Best of the 12 throughout, and the earliest. |
| Very nice standing crop. |
| Heavy crop, badly laid in places. |
| Also laid here and there. |
| Poor standing crop, fell off during latter part of growth; early ripe. |



LEA OATS. LB. PER ⅛ ACRE.

| 9 | 4 | 6 | 8 | 10 | 2 |
|---|---|---|---|---|---|
| Nitrate. | Nitrate on braird. | Nitrate on braird. | Nitrate and sulphate. | 1½ Nitrate. | 1½ Nitrate on braird. |
| Super. Salt. | Super. Salt. | Super. Muriate. | Super. Muriate. | Super. Muriate. | Super. Muriate. |
| 241 | 238 | 162[1] | 224 | 213[1] | 241[2] |
| 371 | 378 | 364 | 360 | 411 | 440 |
| 151 | 184 | 172½ | 153 | 152½ | 182 |
| 431 | 466 | 410 | 486 | 410 | 371 |
| 672 | 672 | 840 | 756 | 840 | 868 |
| 392 | 560 | 532 | 504 | 392 | 532 |

[2] Slightly lodged.

## FINELY GROUND PHOSPHATES AS A TURNIP MANURE.

### EXPERIMENT XXIII.

The value of ground phosphate as a turnip manure has been the subject of many experiments, especially in Aberdeenshire, where the utility of that form of phosphate was first brought forcibly into notice by the untiring efforts of Mr Thomas Jamieson. The object of this experiment was not so much to exhibit the manurial value of insoluble phosphates, as to compare the relative efficacy of a number of the natural phosphates now in the market when applied in as nearly as possible *the same state of fineness.*

The improved machinery for grinding phosphates that is now in use makes it possible to obtain ground phosphates in almost any grade of fineness, and enables us to overcome one of the chief difficulties that had to be met when comparing the value of ground phosphates in former years. It was noticed at Pumpherston Experimental Station that the relative efficacy of different kinds of phosphate fluctuated in different years, and that the superiority of one kind of phosphate over another was not due so much to the specific character of the minerals themselves as to the different degrees of fineness in which they were applied. It seemed to the Chemical Committee that an experiment might now be made to determine the relative efficacy of the ground phosphates in common use when applied in a definite state of fineness.

The degree of fineness aimed at was that of a flour so fine as to pass almost entirely through a sieve of No. 100 wire-cloth; that is, a sieve of wire-gauze containing somewhere about 10,000 holes per square inch—a fineness beyond which it is not expedient to go either on the ground of expense or of utility. The effort to obtain this grade of fineness was not quite successful, but a sufficiently near approximation was attained for practical purposes.

The following were the phosphates employed in this experiment, their composition, and the quantity employed so as to supply phosphoric acid to each plot at the rate of 100 lb. per acre:—

| No. | Percentage of phosphoric acid. | Quantity per acre. lb |
|---|---|---|
| 1. Algerian | 28 7 | 349 |
| 2. Belgian | 20 2 | 495 |
| 3. Carolina (Charleston) | 27.6 | 362 |

| No. | Percentage of phosphoric acid. | Quantity per acre. lb. |
|---|---|---|
| 4. Florida Rock . . . | 36.3 | 275 |
| 5. No phosphate . . . | ... | ... |
| 6. Phosphatic guano . . . | 33.3 | 300 |
| 7. Slag . . . | 18.4 | 543 |
| 8. Superphosphate . . . | 15.1 | 663 |
| 9. Florida Peace River . . | 32.6 | 307 |

Besides the main question another was tried, which had the practical effect of securing that the experiment was done in duplicate on each farm. Two sets of manures were given to each farmer, one of them to be applied on the winter furrow in February and the other at the time of sowing. Along with the phosphates were applied muriate of potash and sulphate of ammonia, each at the rate of half a cwt. per acre.

The experiment was laid down on thirty-seven farms; but such was the inclemency of the season, the prevalence of floods, and the ravages of finger-and-toe, that not one-half of the trials were thought worth reporting, and of the remainder a considerable number were either imperfect or regarded by the experimenters as quite unreliable; so that out of the whole number only eleven have been found capable of yielding fairly reliable information. Some of these were affected by finger-and-toe, although not very seriously; and while they exhibit some discrepancies, these are, in all probability, due chiefly to the different character of the soils in which the manures were tried, and on that account I have thought it advisable to publish them. The details are on Tables I. and II. (pp. 456, 457). Taken over all, the averages obtained show that the duplicates corroborate each other, and we may regard the indications given as fairly trustworthy. As the final result of the experiment, the phosphates may be classified in the following order as regards their efficacy:—

| | Applied in Feb. | | Applied in April. | | Average. | |
|---|---|---|---|---|---|---|
| | tons | cwt | tons | cwt. | tons | cwt. |
| Superphosphate . . . . | 17 | 2 | 17 | 11 | 17 | 6 |
| Slag . . . . . . | 16 | 16 | 16 | 4 | 16 | 10 |
| Carolina (Charleston) . . | 15 | 0 | 15 | 0 | 15 | 0 |
| Phosphatic guano . . . | 14 | 14 | 15 | 5 | 15 | 0 |
| Algerian . . . . . | 14 | 4 | 15 | 7 | 14 | 15 |
| Belgian . . . . . . | 13 | 18 | 14 | 10 | 14 | 4 |
| Florida Peace River . . | 13 | 9 | 14 | 8 | 13 | 18 |
| Florida Rock . . . . | 11 | 18 | 12 | 14 | 12 | 6 |
| Average . . | 14 | 13 | 15 | 2 | ... | ... |

At the head of the list stands superphosphate, which, despite its soluble character and the extreme wetness of the season, has not suffered much if any loss by being washed down to the drains. Close behind it is slag, with a diminished yield of 16 cwt. per acre. Carolina phosphate and phosphatic guano have yielded 2 tons 6 cwt. less than the superphosphate, the Algerian phosphate 2 tons 11 cwt. less, the Belgian 3 tons 2 cwt. less, and the Florida phosphate fully 4 tons less per acre than was obtained by the superphosphate. Considering the adverse circumstances in which the crops were grown, and the small number of them, we cannot regard these data as more than rough indications of the relative efficacy of the phosphates concerned, but they suffice to show that the kind of phosphate, as distinct from mere fineness of grinding, is of some importance. The advantage of using one or other of them depends also on the price per unit at which the phosphate can be bought.

The plot that got no phosphate averaged 9¼ tons per acre. Deducting that from the other averages, we see what is the amount of increase due to the phosphates applied. Knowing this and the cost of the phosphates, it is easy to see what the balance of profit is. We may value the turnips at 7s. per ton and obtain the following:—

| | Increase. | | Cost of phosphates. | Profit. | |
|---|---|---|---|---|---|
| | tons | cwt. | s. | s. | d. |
| Superphosphate | 8 | 6 | 19 | 40 | 6 |
| Slag | 7 | 10 | 11 | 41 | 6 |
| Carolina | 6 | 0 | 8 | 34 | 0 |
| Phosphatic guano | 6 | 0 | 14 | 28 | 0 |
| Algerian | 5 | 15 | 8 | 32 | 0 |
| Belgian | 5 | 4 | 8 | 24 | 6 |

In the circumstances, the most that can be deduced from these figures is that superphosphate and slag have been about equally economical, that Carolina and Algerian have been less economical, and Belgian and Phosphatic Guano still less so.

One other result of the experiment is deserving of notice, and that is the comparatively small difference in the efficacy of the manures when applied in February and April—viz., 9 cwt. per acre in favour of the April application. Considering that sulphate of ammonia formed part of the manure, it would not have been surprising if the difference had been greater; but it shows how little liable that form of nitrogenous manure is to be washed away during the cold season of the year before nitrification has become active in the soil.

*Experimenters.*

Mr G. F. Barron, Meikle Endovie, Alford.
Mr George Wilken, Waterside of Forbes, Alford.
Mr Joseph Brown, Little Endovie, do.
Mr John Reid, Nether Kildrummy, do.
Mr Alex. Grassick, Knowhead, do.
Mr Middleton, Cushiestown, Wartle.
Mr Leslie Durno, Mains of Glack, Old Meldrum.
Mr George Bruce, Heatherwick, Inverurie.
Mr James Stephen, Conglass, do.
Mr Alex. Keith, Kinnermit, Turriff.
Mr Wm. Slessor, Shielburn, do.
Mr Alex. Slessor, Raecloch, do.
Dr Milne, Darra, do.
Messrs J. & S. D. Milne, Mains of Laithers, Turriff.
Mr Wm. Anderson, Backhill, Turriff.
Mr Alex. Jack, Backmill, do.
Mr Joseph Brown, Dorlaithers, do.
Mr Adam Davidson, Boghead, do.
Mr Wm. Norrie, Cairnhill, do.
Mr Wm. Strachan, Muirden, do.
Mr John Morrison, Little Feithhill, Turriff.
Mr James Wilson, Arnhall, Huntly.
Mr Wm. Scott, Corsiestane, do.
Mr Robt. Coutts, Newton, Kincardine O'Neil.
Mr James Milne, Cairnhill, Muchalls.
Mr John Pratt, The Green, Banchory.
Mr James Cran, Knockandoch, Whitehouse.
Mr David Watson, Brunthill, Fraserburgh.
Mr A. S. Morrison, Stonebriggs, do.
Mr James Dunn, Easter Kincraigie, Lumphanan.
Mr Lewis Strachan, Tulloch, do.
Mr David Davidson, Cabra, Mintlaw.
Mr George Watson, Middlemuir, Strichen.
Mr Wm. Chapman, Woodhead, do.
Mr H. Fraser, Hotel, Aberdour, do.
Mr James Kennedy, Greenhall, Insch.
Mr John Davidson, Gowanwell, Auchnagatt.

[Tables

TABLE I.—EXPERIMENT XXIII. PHOSPHATES APPLIED SOME WEEKS BEFORE SOWING.

| | 1 Algerian. | | 2 Belgian | | 3 Carolina. | | 4 Florida Rock. | | 5 Nothing | | 6 Phosphatic guano. | | 7 Slag | | 8 Super-phosphate. | | 9 Florida Peace River. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | tons | cwt. | tons | cwt. | tons | cwt | tons | cwt | tons | cwt. | tons | cwt. | tons | cwt | tons | cwt. | tons | cwt. |
| 1. Mains of Laithers, Turriff | 7 | 19 | 11 | 5 | 9 | 2½ | 7 | 7 | 7 | 10 | 11 | 12 | 12 | 17½ | 11 | 1 | 9 | 17 |
| 2. Shielburn, " | 11 | 10½ | 11 | 0 | 14 | 8 | 10 | 11 | 6 | 16 | 9 | 6½ | 17 | 15 | 18 | 0 | 15 | 10 |
| 3. Dorlaithers, " | 10 | 7½ | 7 | 15 | 9 | 1 | 5 | 15 | 3 | 1 | 7 | 15 | 13 | 7 | 13 | 17 | 7 | 7½ |
| 4. Boghead, " | 18 | 4 | 16 | 1 | 18 | 7 | 14 | 10 | 15 | 0 | 17 | 3 | 15 | 14 | 18 | 4 | 16 | 7 |
| 5. Upper Muirden, " | 12 | 0 | 12 | 5 | 11 | 2½ | 6 | 0 | 4 | 12½ | 11 | 17½ | 12 | 15 | 14 | 5 | 10 | 2½ |
| 6. Feithhill, " | 14 | 8 | 14 | 13 | 18 | 15 | 17 | 14 | 12 | 10 | 17 | 11 | 19 | 14 | 18 | 14 | 17 | 10 |
| 7. Woodhead, Aberdour . | 11 | 9 | 12 | 0 | 10 | 14 | 8 | 17 | 3 | 8 | 10 | 14 | 11 | 9 | 12 | 11 | 9 | 14 |
| 8. New Aberdour . . | 12 | 11 | 11 | 8½ | 11 | 8½ | 9 | 2 | 8 | 0 | 14 | 16 | 13 | 5 | 16 | 0 | 8 | 0 |
| 9. Brunthill, Fraserburgh . | 22 | 5 | 20 | 11 | 22 | 11 | 20 | 5 | 21 | 2 | 23 | 12 | 27 | 18 | 22 | 17 | 18 | 11 |
| 10. Stonebriggs, " . | 13 | 0 | 13 | 15 | 14 | 12 | 9 | 9 | 8 | 7 | 11 | 15 | 15 | 10 | 16 | 18 | 13 | 4 |
| 11. Cabra, Mintlaw . . | 22 | 15 | 22 | 7 | 25 | 2 | 21 | 6 | 11 | 0 | 25 | 10 | 24 | 12 | 25 | 18 | 21 | 9 |
| Average . . . | 14 | 4 | 13 | 18 | 15 | 0 | 11 | 18 | 9 | 4 | 14 | 14 | 16 | 16 | 17 | 2 | 13 | 9 |

TABLE II.—EXPERIMENT XXIII. PHOSPHATES APPLIED AT TIME OF SOWING.

| | 1 Algerian. | | 2 Belgian. | | 3 Carolina. | | 4 Florida Rock. | | 5 Nothing. | | 6 Phosphatic guano. | | 7 Slag. | | 8 Super-phosphate. | | 9 Florida Peace River. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. | tons | cwt. |
| 1. Mains of Laithers, Turriff | 13 | 7 | 13 | 0 | 10 | 4 | 8 | 16 | 6 | 2 | 12 | 9½ | 14 | 12 | 15 | 0 | 13 | 12½ |
| 2. Sheilburn, " | 18 | 14 | 19 | 0 | 21 | 3 | 15 | 17 | 12 | 17 | 17 | 6 | 17 | 16½ | 18 | 0 | 15 | 10 |
| 3. Dorlaithers, " | 8 | 1 | 8 | 10 | 11 | 4 | 7 | 11 | 6 | 11 | 12 | 9 | 9 | 17½ | 7 | 12½ | 8 | 0 |
| 4. Boghead, " | 20 | 1 | 17 | 0 | 17 | 14 | 16 | 0 | 14 | 13 | 19 | 3 | 19 | 0 | 19 | 9 | 16 | 16 |
| 5. Upper Muirden, " | 14 | 0 | 12 | 15 | 12 | 7½ | 11 | 2½ | 8 | 2½ | 15 | 10 | 11 | 15 | 18 | 7½ | 13 | 0 |
| 6. Feithhill, " | 14 | 11 | 14 | 6 | 16 | 6 | 16 | 14 | 11 | 9 | 14 | 8 | 17 | 14 | 16 | 14 | 18 | 14 |
| 7. Woodhead, Aberdour . | 12 | 0 | 8 | 11 | 8 | 17 | 3 | 8 | 6 | 0 | 13 | 3 | 13 | 8½ | 13 | 5 | 8 | 11 |
| 8. New Aberdour . . | 12 | 11½ | 10 | 0 | 10 | 11½ | 7 | 14 | 5 | 14 | 6 | 19 | 11 | 14 | 21 | 12½ | 10 | 17 |
| 9. Burnthill, Fraserburgh . | 21 | 14 | 22 | 15 | 22 | 15 | 20 | 11 | 20 | 0 | 22 | 17 | 23 | 8 | 23 | 14 | 18 | 5 |
| 10. Stonebriggs, " . | 14 | 16 | 14 | 5 | 14 | 12 | 12 | 2 | 7 | 2 | 13 | 11 | 18 | 7 | 19 | 9 | 15 | 7 |
| 11. Cabra, Mintlaw . . | 19 | 1 | 18 | 18 | 19 | 1 | 19 | 16 | 10 | 1 | 19 | 16 | 20 | 16 | 20 | 7 | 19 | 13 |
| Average . . . | 15 | 7 | 14 | 10 | 15 | 0 | 12 | 14 | 9 | 17 | 15 | 5 | 16 | 4 | 17 | 11 | 14 | 8 |

NOTES.

1. Light soil on clay-slate. Brydon's monarch swede.
2. Thin black soil on clay-slate. Aberdeen yellows.
3. Poor black soil on clay slate. Early yellows.
4. Good loam, somewhat sandy. Smith's purple-top swede.
5. Thin light black soil, retentive subsoil. Purple-top yellows.
6. Black turfy soil on slaty bottom. Green-top yellows.
7. Light gravelly soil. Aberdeen yellows.
8. Light black soil, poor subsoil. Aberdeen yellows.
9. Light black soil. Aberdeen yellows.
10. Light gravelly soil. Aberdeen yellows.
11. Yellow, dry, light, stony soil. Aberdeen yellows.

## DRIFFIELD'S "ACHILLES" TURNIP.

The reputation of this turnip for resisting the attack of the organism causing "finger-and-toe" disease in the turnip crop was brought before the notice of the Chemical Committee, and it was resolved to give the seed a trial in widely different parts of Scotland.

Mr Thomas N. Driffield, Brafferton, Helperby, York, to whom the introduction of this turnip is due, supplied the Society with four parcels of seed, one of which was sent to Mr Adam Logan, Ferney Castle, Reston, Berwickshire; another to Mr James Smith, Farm of Bogs, Enzie, Banffshire; and another to Mr James Shields, Dolphingstone, Tranent, Haddingtonshire, that they might be sown upon land known to be affected with finger-and-toe. On only one of these farms—viz., that of Mr Logan's—did the seed show itself to be disease-resisting, but its success there was very marked.

The seed was sown on a field which had not been limed for thirty-seven years, and where, on previous rotations, finger-and-toe had been prevalent. The disease was observed in the field at the time of singling, and before the summer was well advanced many turnips of the Fosterton hybrid variety began to die off.

The Achilles turnip seed was sown along with the Fosterton seed in alternate pairs of drills, and at the time of lifting a section across the drills was made 20 yards long at a place fairly representing the general growth, and the bulbs taken from six drills of the Achilles turnip was weighed against the neighbouring six drills of Fostertons with the following results:—

| | | |
|---|---|---|
| Achilles turnip . . | 70½ stones | = 22 tons per acre. |
| Fosterton hybrid . | 7 stones 1 lb. = | 2⅕ " |

On another piece of land not affected with finger-and-toe the two kinds of turnips were similarly grown, and lifted in order to compare the weight of the crops produced by the two varieties of seed, and the results were—

| | | |
|---|---|---|
| Achilles turnip . . | 68 stones = | 21¼ tons per acre. |
| Fosterton hybrid . . | 72 stones = | 22½ " |

The Achilles turnip did not entirely escape the disease, but it was noticed that where the bulbs were affected the disease confined itself to the tap-root, leaving the mass of the bulb unaffected.

Samples, thirty each, of the two kinds of turnips were taken and analysed, with the following results:—

| | Achilles. | Fosterton. |
|---|---|---|
| Water | 92.19 | 91.40 |
| Solids | 7.81 | 8.60 |
| | 100.00 | 100.00 |
| Solids contained— | | |
| Albuminoids | 5.47 | 5.03 |
| Amides | 4.59 | 3.94 |
| Carbohydrates, &c. | 73.14 | 74.96 |
| Woody fibre | 9.35 | 9.60 |
| Ash | 7.45 | 6.47 |
| | 100.00 | 100.00 |

Unfortunately the success attending the Achilles seed at Ferney Castle was not confirmed by the experiments on the other farms. On one farm the report stated that the Achilles turnips were even worse affected than the others on the field.

It seems probable that the success of the Achilles turnip as a disease-resisting variety is much affected by the nature of the soil on which it is grown, but what the condition or composition of soil is that is favourable to it has yet to be determined.

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## FEEDING EXPERIMENT TO COMPARE THE FEEDING VALUE OF DRIED GRAINS AND OTHER HOME-MADE FODDERS WITH THAT OF LINSEED-CAKE.

Brewery draff or brewer's grains has long been used as a fodder for milch cows, and much appreciated by dairymen; but as three-fourths of its weight is due to water, the expense of carriage has much restricted the area of its consumption. It is derived from barley, and differs from barley chiefly in respect that the starch, which constitutes two-thirds of the weight of the barley, has been removed by converting it into sugar, and dissolving it out. The residue consists largely of albuminoid matter, and is therefore a more concentrated kind of fodder than the original barley. During recent years very efficient drying machinery has been introduced, enabling the water, which is the one objectionable ingredient in draff, to be for the most part removed, and so converting it into a dry sweet-flavoured fodder rich in albuminoids and oil, and closely resembling oilcake in its composition.

In a similar manner the dreg or pot-ale of distilleries, most of which was formerly run into drains and water-courses, is now converted into a rich feeding-stuff by precipitating the solid matter in settling-tanks, and then subjecting it to a thorough drying operation. The materials used for the production of sugar by distillers may be barley or maize or other cereal grains in any proportions, and the dried dreg obtained varies in composition accordingly, so that in some circumstances the dried distillery grains form a very concentrated feeding-stuff.

In order to test the comparative value of linseed-cake and dried grains, or rather to test the more general question as to whether the albuminoid matter and oil contained in linseed-cake was, as is generally supposed, superior in feeding effect to the albuminoids and oil contained in other kinds of concentrated fodder, an experiment was undertaken by Mr Milne, Mains of Laithers, in the spring of last year. Three equal lots of well-bred Irish heifers rising two years old, which had been on the farm since 1892, were selected for the purpose. They were well forward in condition at the time, and each lot consisted of eight cattle. They were fed as follows, per head per day:—

| Lot. | | lb. |
|---|---|---|
| I. | Swedes | 60 |
| | Linseed-cake | 6 |
| II. | Swedes | 60 |
| | Dried grains | 3 |
| | Decorticated cotton-cake | 3 |
| III. | Swedes | 60 |
| | Clover and ryegrass-hay *ad libitum*. | |

The linseed-cake used was specially made in Aberdeen from pure linseed, and the mixture of dried grains and cotton-cake consumed by Lot II. was such as to produce a feeding-stuff having a similar analysis to the linseed-cake. The three lots received oat-straw *ad libitum*. It was supplied to each lot in bundles of 8 lb. each daily, and any that was not eaten was collected and weighed, and the weight deducted from the daily supply. The litter used was either peat or mill-dust.

The experiment was continued for fourteen weeks, during which the cattle were regularly weighed seven times, and the following was the result of the whole experiment:—

| Lot. | Total increase. cwt. | qr. | lb. | Increase per head per day. lb. |
|---|---|---|---|---|
| I. Linseed-cake | 9 | 3 | 10 | 1.40 |
| II. Grains and decorticated cotton-cake | 10 | 3 | 7 | 1.54 |
| III. Clover and ryegrass-hay | 6 | 1 | 26 | .93 |

The amounts of straw consumed by the three lots during the first twelve weeks were as follows:—

| Lot. | | Total. lb. | Per head per day. lb. |
|---|---|---|---|
| I. | Oat-straw | 5137 | 7.64 |
| II. | " | 5442½ | 8.10 |
| III. | " | 252 | .5 |
| | Hay | 9230½ | 13.74 |

The superiority of the lot fed on grains and cotton-cake was so marked, that it was considered expedient not to publish the results until they had been confirmed by further experiments. Accordingly, Mr Milne carried out a similar experiment immediately thereafter with the only suitable cattle he had at the time. It began on 1st March and lasted till 10th May. The cattle employed were a lot of small backward Irish steers that had been purchased shortly before the experiment began. They were a very equal lot, and he divided them into three lots of four each.

The former supply of grains having been exhausted, a fresh supply of grains, specially prepared and supplied gratis by the Scottish Grains Company, was used, and the three lots were fed as follows:—

| Lot. | | Per head per day. lb. |
|---|---|---|
| I. | Swedes | 60 |
| | Pure linseed-cake | 6 |
| II. | Swedes | 60 |
| | Special dried grains | 6 |
| III. | Swedes | 60 |
| | Decorticated cotton-cake | 3 |
| | Barley-bran | 3 |

The experiment lasted ten weeks, and the following were the results:—

| Lot. | Total increase. cwt. | qr. | lb. | Increase per head per day. lb. | Straw per head per day. lb. |
|---|---|---|---|---|---|
| I. | 4 | 3 | 14 | 1.95 | 7.77 |
| II. | 6 | 2 | 23 | 2.68 | 7.23 |
| III. | 5 | 0 | 18 | 2.06 | 7.73 |

The results of this experiment confirmed in a general manner those of the larger one; but as former experience has shown that feeding experiments in which less than eight animals are contained in each lot are not reliable, it was resolved to await the results of an experiment on a larger scale before publishing the details of these two experiments.

The subject was discussed by the Chemical Committee, and in view of the unexpected character of the results obtained, and of the great importance of the matter from an economic point of view, it was resolved to ask Mr Milne to conduct another

experiment on a larger scale. With his usual zeal where any experimental work that promises to be of service to agriculture is concerned, Mr Milne at once consented, and careful preparations were made for commencing it in the coming winter. Samples of the various kinds of feeding-stuffs were analysed, and from these were selected those which were to be used in the experiment, and the entire quantity required was forwarded and stored some time before the experiment began.

Forty well-bred Irish steers were selected and divided into five lots of eight each, and as there were still four available besides these, Mr Milne set them aside for a special experiment, which has turned out to be one of unusual interest. The method of the experiment was, that all the lots should receive yellow turnips at the rate of 30 lb. per head per day. The object in view in restricting the turnips to that small amount was to enable the concentrated fodders to be given in larger quantity, whereby the specific effects due to them would be all the more pronounced. In the next place, the cake, grains, and other concentrated fodders were to be supplied in such a manner as to present substances of as nearly as possible similar analysis—that is to say, containing as nearly as possible the same proportion of albuminoids and oil. The quantity of such concentrated fodders was fixed at 8 lb. per head per day. Oat-straw was given to all the lots *ad libitum*, and the exact amount consumed by each pair of steers was weighed in the manner already described. A well-known brand of linseed-cake was chosen—viz., Miller's St Petersburg—and it formed the standard for the composition of all the other concentrated feeding-stuffs. A home-made pure linseed-cake would have done quite as well, but as Miller's St Petersburg linseed-cake has a deservedly high reputation, it was selected as least liable to cavil. The analyses of the feeding-stuffs eventually selected are given at the end of this report. It was deemed advisable to compare the feeding effect of wet grains with that of the dry grains, and for that purpose a bi-weekly supply of wet grains was obtained from two malt distilleries, and frequent samples of them were sent for analysis during the course of the experiment, lest there should be any considerable fluctuation in their composition from week to week. The dried grains were supplied by Messrs J. & J. Cunningham free of cost—viz., North British Distillery grains. To these were added decorticated cotton-cake in quantity requisite to bring up the analysis to that of the linseed-cake. Another consignment of dried grains was supplied free of cost by the Scottish Grains Company. These were mixed grains closely resembling the linseed-cake in analysis, so that no cotton-cake required to be given along with them. Another lot received a mixture of a feeding meat-meal and Russian barley of which a

considerable quantity was being imported at a very cheap rate. The analyses of these fodders are as follow:—

ANALYSES OF FODDERS USED IN FEEDING EXPERIMENT AT MAINS OF LAITHERS, 1894-95.

| | Albumen. | Oil. | Carbo-hydrates. | Woody fibre. | Ash. | Water. |
|---|---|---|---|---|---|---|
| Miller's St Petersburg linseed-cake . . . . . . | 32.81 | 10.60 | 31.59 | 5.25 | 6.70 | 13.05 |
| Dried grains . . . . . | 24.28 | 9.20 | 43.15 | 10.85 | 2.15 | 10.37 |
| " . . . . . . | 28.22 | 7.93 | 43.26 | 7.27 | 2.40 | 10.92 |
| Decorticated cotton-cake-meal . | 47.91 | 14.25 | 19.55 | 3.97 | 5.27 | 9.05 |
| Ground Russian barley . . | 12.03 | 1.07 | 63.75 | 5.77 | 2.40 | 15.00 |
| Liebig's meat-meal . . . | 68.91 | 16.20 | 2.32 | .65 | 1.82 | 10.10 |
| Barley-bran . . . . . | 13.78 | 3.75 | 55.35 | 9 05 | 4.72 | 13.35 |
| Draff, Rothes . . . . . | 5.05 | 2.01 | 12.69 | 3.19 | .86 | 76.20 |
| " " . . . . . | 5.12 | 2.07 | 12.81 | 3.32 | .81 | 75.87 |
| " " . . . . . | 4.96 | 2.25 | 13.17 | 2.97 | .75 | 75.90 |
| Draff, Glen Grant . . . . | 6.62 | 2.07 | 14.85 | 3.35 | .88 | 72.23 |
| " " . . . . . | 5.92 | 1.98 | 14.34 | 3.10 | .92 | 73.74 |
| " " . . . . . | 5.56 | 2.28 | 14.20 | 3.26 | .90 | 73.80 |
| Early Angus oat-straw . . | 2.80* | 4.41 | 40 80 | 31.79 | 5.60 | 14 60 |
| Potato-oat-straw . . . | 3.89† | 4.56 | 44.52 | 28.31 | 4.32 | 13.40 |

* Containing amides, .38. † Containing amides, .40.

In all these cases the feeding-stuffs were brought up to the standard of the linseed-cake. The extra lot of four cattle got no turnips whatever, but were fed solely upon barley-bran and oat-straw. There is a widespread notion that cattle cannot be properly or successfully fed without turnips, and it was with the view of testing that as much as anything else that Mr Milne made the sixth lot with the four cattle he had to spare. The cattle were weighed fortnightly as usual, but it will suffice to give the weight of each individual and of each lot at the beginning of the experiment, and every fourth week thereafter. These details are given on Tables I., II., III., IV., V., and VI. (pp. 467, 468, 469).

Table IV. is seen to be incomplete. No. 2 of that lot went off feed from indigestion on 29th January, and No. 3 did likewise on 10th February. Whether their indigestion was directly due to the fodder they were eating, is hard to say. The others of the lot remained healthy and mostly made good progress; but it may be that their digestive power was weaker than the others, and 8 lb. per day of so concentrated a kind of grains may have been too much for them.

A mere glance at these six tables will show how considerable

are the differences in the progress of cattle while living on exactly the same fare and in the same circumstances, and how necessary it is in such experiments that each lot of animals used for feeding experiments should contain *at least* eight. In almost every lot there are members who have not made half the normal progress, and circumstances have occurred to many that have interfered with their feeding quite irrespective of the nature of their fodder. In Lot I. the first five cattle made very equal progress and fed well, the next three did not do half so well. Lot II. was a very equal lot as regards progress, except No. 8, that made almost no progress. Lot III. was peculiar, whether from the nature of the food or unfortunate selection, I am unable to say—probably from both reasons. Five out of the eight went back for a time in their feeding after making good progress, some in February and some in March. I should not be satisfied that the nature of the food was mainly responsible for the low results of that lot until I had tried it on a larger scale, and I am the more inclined to the view that the lot had bad luck from a comparison of its results with those of the former experiments, in which a similar dietary proved most successful. It is unnecessary to refer specially to each of the six lots, as a mere glance at the tables shows exactly the position of matters. It may, however, assist in taking a general view of the whole experiment if the average gain per head per month is shown separately, as in the following table:—

AVERAGE GAIN PER HEAD PER MONTH.

| Lot. | | Dec. | Jan. | Feb. | March. | Average per lot. |
|---|---|---|---|---|---|---|
| | | lb. | lb | lb. | lb. | |
| I. | Linseed-cake . . . | 30 | 45½ | 21½ | 29 | 31½ |
| II. | Wet grains, decorticated cotton-cake, and linseed-oil . | 33 | 53 | 13 | 32 | 33 |
| III. | Dried grains and decorticated cotton-cake . . . | 25 | 42½ | 2½ | 24 | 23½ |
| IV. | Special dried grains . . | 42 | 49 | 22 | 27 | 35 |
| V. | Meat-meal, barley, and linseed-oil . . . . . . | 52½ | 41 | 18½ | 23½ | 34 |
| VI. | Barley-bran (no turnips) . . | 30½ | 55 | 44 | 16½ | 36½ |
| | Average per month | 35½ | 47½ | 20 | 25⅓ | ... |

The extraordinary drop which took place in February was, of course, due to the unprecedented cold of that month. Mr Milne has a byre in which 120 cattle are housed under one roof. Notwithstanding the heat given out by so great a number of

large animals, the temperature of the byre in the morning was on four occasions below freezing-point, while the outside temperature was at two periods below zero for several days. Lot VI., which got no turnips, did not suffer so much in February as the others, presumably because the animals had not to part with so much of their heat in raising 30 lb. of turnips from near the freezing-point to the temperature of their bodies. The by-fodder consumed by that lot differed entirely from the other lots, having less than half the amount of albumen, only about one-third the amount of oil, but nearly double the amount of carbohydrates—what is known as the nutrient ratio was therefore much wider in this lot than in the others. See table of analyses of fodder (p. 463). The progress of that lot was very remarkable, and had the experiment stopped at the end of February it would have conveyed the notion that barley-bran and straw was superior to the other kinds of fodder; but, strange to say, their rapid progress received a sudden check during March, and if the experiment had continued another month, it is probable that the lot would not have ended, as it has done, superior to all the others. Another circumstance to be remembered is, that it contained only four cattle, and that is not a number capable of yielding reliable information.

All that is needed to complete the information supplied by this experiment is the cost of the feeding of each lot. The prices given in the subjoined statement are those of December when the stuffs were bought.

FODDERS CONSUMED IN SIXTEEN WEEKS, AND ESTIMATED COST.

LOT I. *Linseed-cake. Eight Cattle.*

| | | Per ton. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | lb. | *s.* | *d.* | £ | *s.* | *d.* | £ | *s.* | *d.* |
| Turnips . . . . . | 26,880 | 8 | 0 | 4 | 16 | 0 | | | |
| Miller's St Petersburg cake | 7,168 | 145 | 0 | 23 | 4 | 0 | | | |
| Oat-straw . . . . | 9,927½ | 40 | 0 | 8 | 17 | 3 | | | |
| | | | | | | | 36 | 17 | 3 |

Cost per head per week, 5s. 9d.

LOT II. *Wet Draff and Decorticated Cotton-meal. Eight Cattle.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Turnips . . . . . | 26,880 | 8 | 0 | 4 | 16 | 0 | | | |
| Wet draff, including railway carriage . . . . . | 11,520 | 20 | 0 | 5 | 2 | 10 | | | |
| Decorticated cotton-meal . | 4,176 | 120 | 0 | 11 | 3 | 8 | | | |
| Linseed-oil . . . . . | 144 | 400 | 0 | 1 | 5 | 8 | | | |
| Oat-straw . . . . | 8,111 | 40 | 0 | 7 | 4 | 10 | | | |
| | | | | | | | 29 | 13 | 0 |

Cost per head per week, 4s. 7½d.

LOT III. *Dried Grains and Decorticated Cotton-meal. Eight Cattle.*

| | lb. | Per ton s. | d. | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|
| Turnips . . . . . | 26,880 | 8 | 0 | 4 | 16 | 0 | | | |
| Dried grains . . . . | 4,778 | 77 | 6 | 8 | 5 | 2 | | | |
| Decorticated cotton-meal . | 2,389 | 120 | 0 | 6 | 8 | 0 | | | |
| Oat-straw . . . . . | 8,393½ | 40 | 0 | 7 | 9 | 10 | | | |
| | | | | | | | 26 | 19 | 0 |

Cost per head per week, 4s. 2½d.

LOT IV. *Special Dried Grains. Six Cattle.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Turnips . . . . . | 26,880 | 8 | 0 | 4 | 16 | 0 | | | |
| Special dried grains . . | 7,168 | 85 | 0 | 13 | 12 | 0 | | | |
| Oat-straw . . . . . | 7,120 | 40 | 0 | 6 | 7 | 1 | | | |
| | | | | | | | 24 | 15 | 1 |

Cost per head per week, 3s. 10½d.

LOT V. *Meat-meal and Russian Barley. Eight Cattle.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Turnips . . . . . | 26,880 | 8 | 0 | 4 | 16 | 0 | | | |
| Meat-meal . . . . . | 2,648 | 180 | 0 | 10 | 12 | 9 | | | |
| Russian barley . . . . | 4,232 | 80 | 0 | 7 | 11 | 2 | | | |
| Linseed-oil . . . . . | 288 | 400 | 0 | 2 | 11 | 5 | | | |
| Oat-straw . . . . . | 7,630½ | 40 | 0 | 6 | 16 | 3 | | | |
| | | | | | | | 32 | 7 | 7 |

Cost per head per week, 5s. 0¾d.

LOT VI. *Barley-bran. Four Cattle.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Barley-bran . . . . | 6,812 | 75 | 0 | 11 | 8 | 0 | | | |
| Oat-straw . . . . . | 3,360½ | 40 | 0 | 3 | 0 | 0 | | | |
| | | | | | | | 14 | 8 | 0 |

Cost per head per week, 4s. 6d.

It is apparent from this statement that the linseed-cake lot were fed dearest—viz., 5s. 9d. per head per week; and the lot fed with special dried grains of the same composition as the linseed-cake were fed cheapest—viz., 3s. 10½d. per head per week.

These experiments, along with that of Mr Logan, p. 433, warrant us in concluding that there is no special inscrutable virtue in linseed-cake as compared with other forms of concentrated fodder, but that other and less expensive feeding-stuffs may produce results quite as favourable to the health and progress of feeding animals.

[TABLES

TABLE I.—LOT I.

*Weekly Ration*—Yellow turnips, 1680 lb.; Miller's St Petersburg linseed-cake, 448 lb.

| | Dec. 6. | | | Jan. 3. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | lb. |
| 1 | 8 | 3 | 25 | 9 | 1 | 21 | 10 | 0 | 3 | 10 | 0 | 20 | 10 | 2 | 2 | 1 | 2 | 5 | 2834 |
| 2 | 8 | 1 | 9 | 8 | 2 | 21 | 9 | 1 | 0 | 9 | 1 | 21 | 9 | 3 | 4 | 1 | 1 | 23 | |
| 3 | 9 | 2 | 25 | 10 | 0 | 0 | 10 | 1 | 4 | 10 | 2 | 9 | 11 | 0 | 5 | 1 | 1 | 8 | 2938½ |
| 4 | 9 | 1 | 9 | 9 | 2 | 17 | 10 | 1 | 14 | 10 | 1 | 20 | 10 | 3 | 16 | 1 | 2 | 7 | |
| 5 | 8 | 3 | 7 | 8 | 3 | 25 | 9 | 1 | 25 | 9 | 2 | 14 | 9 | 3 | 25 | 1 | 0 | 18 | 2103 |
| 6 | 9 | 1 | 16 | 9 | 2 | 24 | 9 | 3 | 24 | 9 | 3 | 9 | 9 | 3 | 24 | 0 | 2 | 8 | |
| 7 | 8 | 2 | 12 | 8 | 3 | 7 | 9 | 1 | 0 | 9 | 1 | 12 | 9 | 1 | 16 | 0 | 3 | 4 | 2052 |
| 8 | 9 | 1 | 10 | 9 | 1 | 16 | 9 | 1 | 5 | 10 | 0 | 3 | 9 | 3 | 13 | 0 | 1 | 21 | |
| Total | 72 | 2 | 1 | 74 | 2 | 19 | 77 | 3 | 19 | 79 | 1 | 24 | 81 | 1 | 21 | 8 | 3 | 10 | 9927½ |
| | | | | lb. | | | lb. | | | lb. | | | lb. | | | lb. | | | |
| Gain per month | | | | 242 | | | 364 | | | 173 | | | 231 | | | =1010 | | | ... |
| Average gain per head per month | | | | 30¼ | | | 45½ | | | 21½ | | | 29 | | | ... | | | ... |

TABLE II.—LOT II.

*Weekly Ration*—Yellow turnips, 1680 lb.; wet draff, 720 lb.; decorticated cotton-cake, 261 lb.; linseed-oil, 9 lb.

| | Dec. 6. | | | Jan. 3. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | lb. |
| 1 | 8 | 3 | 7 | 9 | 1 | 0 | 9 | 3 | 10 | 10 | 0 | 0 | 10 | 1 | 2 | 1 | 1 | 23 | 1814½ |
| 2 | 8 | 2 | 0 | 8 | 3 | 4 | 9 | 1 | 18 | 9 | 1 | 9 | 9 | 2 | 11 | 1 | 0 | 18 | |
| 3 | 8 | 2 | 11 | 8 | 3 | 0 | 9 | 2 | 0 | 9 | 2 | 16 | 9 | 3 | 9 | 1 | 0 | 26 | 2162½ |
| 4 | 7 | 2 | 0 | 7 | 3 | 0 | 7 | 3 | 21 | 8 | 0 | 12 | 8 | 2 | 18 | 2 | 0 | 11 | |
| 5 | 10 | 0 | 0 | 10 | 1 | 20 | 10 | 3 | 9 | 10 | 3 | 4 | 11 | 0 | 15 | 1 | 0 | 15 | 2249½ |
| 6 | 9 | 3 | 17 | 10 | 1 | 7 | 10 | 2 | 14 | 10 | 3 | 0 | 10 | 3 | 23 | 1 | 0 | 6 | |
| 7 | 10 | 0 | 3 | 10 | 2 | 7 | 11 | 0 | 0 | 11 | 1 | 15 | 11 | 3 | 8 | 1 | 3 | 5 | 1884½ |
| 8 | 8 | 1 | 0 | 8 | 0 | 11 | 8 | 2 | 9 | 8 | 2 | 16 | 8 | 2 | 18 | 0 | 1 | 18 | |
| Total | 71 | 2 | 10 | 73 | 3 | 21 | 77 | 2 | 25 | 78 | 2 | 16 | 80 | 3 | 20 | 10 | 1 | 10 | 8111 |
| | | | | lb. | | | lb. | | | lb. | | | lb. | | | lb. | | | |
| Gain per month | | | | 263 | | | 424 | | | 103 | | | 256 | | | =1046 | | | ... |
| Average gain per head per month | | | | 33 | | | 53 | | | 13 | | | 32 | | | ... | | | |

## TABLE III.—Lot III.

*Weekly Ration*—Yellow turnips, 1680 lb.; dried grains, 298⅝ lb.; decorticated cotton-cake, 149⅓ lb.

| | Dec. 6. | | | Jan. 3. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | lb. |
| 1 | 8 | 3 | 24 | 9 | 0 | 24 | 9 | 3 | 0 | 9 | 0 | 23 | 9 | 2 | 19 | 0 | 2 | 23 | 1969½ |
| 2 | 8 | 3 | 14 | 9 | 1 | 0 | 9 | 2 | 6 | 9 | 2 | 22 | 9 | 3 | 15 | 1 | 0 | 1 | |
| 3 | 8 | 0 | 10 | 8 | 1 | 0 | 8 | 2 | 0 | 8 | 1 | 19 | 8 | 2 | 16 | 0 | 2 | 6 | 2208 |
| 4 | 9 | 1 | 17 | 9 | 3 | 14 | 10 | 0 | 7 | 9 | 3 | 14 | 10 | 2 | 2 | 1 | 0 | 13 | |
| 5 | 8 | 2 | 0 | 8 | 3 | 0 | 9 | 0 | 0 | 9 | 1 | 17 | 9 | 3 | 0 | 1 | 1 | 0 | 2056 |
| 6 | 9 | 1 | 14 | 9 | 2 | 18 | 9 | 3 | 14 | 10 | 0 | 14 | 10 | 0 | 13 | 0 | 2 | 27 | |
| 7 | 8 | 3 | 21 | 8 | 2 | 21 | 9 | 1 | 12 | 9 | 1 | 9 | 9 | 2 | 12 | 0 | 2 | 19 | 2160 |
| 8 | 9 | 0 | 0 | 9 | 1 | 0 | 9 | 3 | 7 | 10 | 0 | 4 | 9 | 2 | 14 | 0 | 2 | 14 | |
| Total | 71 | 0 | 16 | 72 | 3 | 21 | 75 | 3 | 18 | 76 | 0 | 10 | 77 | 3 | 7 | 6 | 2 | 19 | 8393½ |
| | | | | lb. | | | lb. | | | lb. | | | lb. | | | lb. | | | |
| Gain per month | | | | 201 | | | 833 | | | 20 | | | 193 | | | =747 | | | ... |
| Average gain per head per month | | | | 25⅛ | | | 41⅝ | | | 2½ | | | 24¼ | | | ... | | | ... |

## TABLE IV.—Lot IV.

*Weekly Ration*—Yellow turnips, 1680 lb.; special dried grains, 448 lb.

| | Dec. 6. | | | Jan. 3. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | lb. |
| 1 | 9 | 0 | 14 | 9 | 2 | 0 | 9 | 3 | 14 | 10 | 1 | 7 | 10 | 1 | 7 | 1 | 0 | 21 | 1905½ |
| 2 | (9 | 1 | 14) | (9 | 2 | 25) | ... | | | ... | | | ... | | | ... | | | |
| 3 | (9 | 2 | 16) | (10 | 2 | 7) | (10 | 0 | 14) | ... | | | ... | | | ... | | | |
| 4 | 8 | 3 | 25 | 9 | 1 | 25 | 9 | 3 | 15 | 10 | 0 | 7 | 10 | 2 | 5 | 1 | 2 | 8 | |
| 5 | 8 | 2 | 17 | 9 | 0 | 4 | 9 | 0 | 16 | 9 | 1 | 21 | 9 | 3 | 6 | 1 | 0 | 17 | 2209½ |
| 6 | 8 | 3 | 7 | 9 | 2 | 2 | 10 | 1 | 0 | 10 | 1 | 20 | 10 | 2 | 27 | 1 | 3 | 20 | |
| 7 | 7 | 3 | 19 | 7 | 3 | 22 | 8 | 1 | 18 | 8 | 2 | 14 | 8 | 2 | 20 | 0 | 3 | 1 | 1589½ |
| 8 | 8 | 2 | 13 | 8 | 3 | 14 | 9 | 1 | 21 | 9 | 1 | 9 | 9 | 2 | 6 | 0 | 3 | 21 | |
| Total | 52 | 0 | 11 | 54 | 1 | 11 | 57 | 0 | 0 | 58 | 0 | 22 | 59 | 2 | 15 | 7 | 2 | 4 | 5704½ |
| | | | | lb. | | | lb. | | | lb. | | | lb. | | | lb. | | | |
| Gain per month | | | | 252 | | | 297 | | | 134 | | | 161 | | | =(844) | | | ... |
| Average gain per head per month | | | | 42 | | | 49½ | | | 26¾ | | | 22⅓ | | | ... | | | ... |

## TABLE V.—Lot V.

*Weekly Ration*—Yellow turnips, 1680 lb.; meat-meal, 166½ lb.; Russian barley, 265½ lb.; linseed-oil, 18.

| | Dec. 6. | | | Jan. 8. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt | qr | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt | qr. | lb. | cwt. | qr. | lb. | lb. |
| 1 | 9 | 3 | 0 | 9 | 3 | 18 | 10 | 0 | 14 | 10 | 0 | 21 | 10 | 1 | 22 | 0 | 2 | 22 | 1805 |
| 2 | 9 | 0 | 0 | 9 | 1 | 24 | 9 | 2 | 14 | 9 | 2 | 14 | 9 | 3 | 4 | 0 | 3 | 4 | |
| 3 | 8 | 0 | 0 | 8 | 2 | 20 | 8 | 3 | 17 | 9 | 2 | 0 | 9 | 2 | 0 | 1 | 2 | 0 | 2111 |
| 4 | 8 | 3 | 4 | 9 | 1 | 5 | 9 | 3 | 3 | 10 | 0 | 7 | 10 | 0 | 3 | 1 | 0 | 27 | |
| 5 | 9 | 0 | 6 | 9 | 1 | 24 | 10 | 0 | 10 | 10 | 0 | 5 | 10 | 1 | 22 | 1 | 1 | 16 | 1854½ |
| 6 | 7 | 3 | 11 | 8 | 1 | 5 | 8 | 3 | 7 | 8 | 3 | 2 | 9 | 1 | 19 | 1 | 2 | 8 | |
| 7 | 8 | 3 | 21 | 9 | 1 | 13 | 10 | 0 | 0 | 10 | 0 | 13 | 10 | 1 | 2 | 1 | 1 | 9 | 1860 |
| 8 | 8 | 2 | 7 | 9 | 0 | 25 | 9 | 1 | 7 | 9 | 2 | 18 | 9 | 3 | 0 | 1 | 0 | 21 | |
| Total | 69 | 3 | 21 | 73 | 2 | 22 | 76 | 2 | 16 | 77 | 3 | 24 | 79 | 2 | 16 | 9 | 2 | 23 | 7630½ |
| | | | | | lb. | | | lb. | | | lb. | | | lb. | | | lb. | | |
| Gain per month | | | | | 421 | | | 330 | | | 148 | | | 188 | | | =1087 | | ... |
| Average gain per head per month | | | | | 52⅝ | | | 41¼ | | | 18½ | | | 23½ | | | ... | | ... |

## TABLE VI.—Lot VI.

*Weekly Ration*—Barley-bran and straw.

| | Dec. 6. | | | Jan. 8. | | | Jan. 31. | | | Feb. 28. | | | March 28. | | | Increase. | | | Barley-bran consumed. | Straw consumed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | cwt. | qr. | lb. | lb. | lb. |
| 1 | 8 | 2 | 1 | 9 | 0 | 6 | 9 | 2 | 0 | 9 | 3 | 7 | 9 | 3 | 17 | 1 | 1 | 16 | 3166 | 1766½ |
| 2 | 8 | 0 | 7 | 8 | 1 | 10 | 8 | 3 | 14 | 9 | 0 | 8 | 9 | 0 | 20 | 1 | 0 | 13 | | |
| 3 | 9 | 0 | 10 | 9 | 1 | 23 | 10 | 0 | 3 | 10 | 1 | 24 | 10 | 2 | 14 | 1 | 2 | 4 | 3646 | 1594 |
| 4 | 9 | 2 | 9 | 9 | 2 | 9 | 10 | 0 | 0 | 10 | 1 | 2 | 10 | 2 | 0 | 0 | 3 | 19 | | |
| Total | 35 | 0 | 27 | 36 | 1 | 20 | 38 | 1 | 17 | 39 | 2 | 13 | 40 | 0 | 23 | 4 | 3 | 24 | ... | ... |
| | | | | | lb. | | | lb. | | | lb. | | | lb. | | | | | lb. | lb. |
| Barley-bran | | | | | 1742 | | | 1868 | | | 1746 | | | 1456 | | | ... | | ... | 3360½ |
| Straw | | | | | 742 | | | 775½ | | | 882½ | | | 960½ | | | ... | | 6812 | ... |
| Gain per month | | | | | 122 | | | 221 | | | 136 | | | 66 | | | ... | | ... | ... |
| Average gain per head per month | | | | | 30½ | | | 55¼ | | | 44 | | | 16½ | | | .. | | ... | ... |

# HIGHLAND AND AGRICULTURAL SOCIETY MACHINERY TRIALS.

The trials of machinery in connection with the Aberdeen Show, 1894, consisted of an exhibition of binders at work, a competitive trial of manure distributors, and the trial of a new patent cultivator.

## Exhibition of Binders at Work.

The exhibition of combined reapers and binders at work was held on Tuesday, 4th September 1894, at Middlefield, Woodside, Aberdeen, on a field kindly granted by Mr Reith.

The weather was favourable, and nearly 200 farmers watched the trials with the keenest interest.

Fifteen machines were entered. Of these, the following twelve took part in the exhibition, viz.:—

J. Bisset & Sons, Blairgowrie—Open-back steel-built binder.
Harrison, M'Gregor, & Co. (Limited), Leigh, Lancashire—(1) The "Albion" binder, with open end; and (2) ditto, with arrangement for closing the end.
H. & R. Hornsby & Sons (Limited), Grantham—No. 12 B binder, adapted for open or closed back.
J. & H. Keyworth & Co., Liverpool—"Adriance" rear-discharge binder.
A. Newlands & Sons, Linlithgow—The "Kearsley" binder.
Ben. Reid & Co., Aberdeen—(1) The Massey-Harris "Brantford" binder, No. 3; and (2) ditto, with sparred web instead of canvas.
W. Reid & Leys, Aberdeen—The Deering pony binder.
Samuelson & Co. (Limited), Banbury—Open-end binder.
W. Smith & Son, Aberdeen—The M'Cormick "Bindlochine" rear-discharge binder.
Walter A. Wood, M. & R. M. Co., London—Open-end binder.

The following members of the Machinery Committee were present to overlook and report upon the results, viz.—Messrs Jonathan Middleton, Clay of Allen, Ross-shire; G. R. Glendinning, Hatton Mains, Wilkieston; George J. Walker, Portlethen; James Hay, Little Ythsie, Tarves; and James D. Park, the Society's engineer. Sir James H. Gibson-Craig, Bart., Chairman of the Board of Directors, was also present.

## Report of the Committee.

The following is the report of the Committee:—

The Directors of the Society having, at the request of makers of binders, decided to omit from this year's trial "the tests of speed, draught, width of cut, and height of stubble," the Committee are unable to do more than report in general terms upon the work accomplished.

The machines were tried only in barley. The crop was moderately light, as nearly even throughout as could well be, very little laid or twisted except on one plot, which was reserved for a trial of all the machines. The test was not quite so severe as might have been desired, yet the field was on the whole admirably suited for the trial.

Half-acre plots were lined off and balloted for by the exhibitors. The machines were taken in relays, only four being at work at one time. This enabled the Committee and the visitors to watch closely the working of the various machines.

As to the character of the work generally, the Committee can speak in the highest terms; it left little to be desired either in the cutting, binding, or any other part of the operation. Stoppages were few in number, and still fewer the loose sheaves.

A novel feature was the Massey-Harris binder with Messrs Ben. Reid & Co.'s new conveyor. This conveyor is a substitute for the ordinary canvas conveyor. It is constructed of slats of wood about an inch broad and an inch apart, which are fitted on pitch chains at each end. The pitch chains run on small sprocket wheels the same diameter as the ordinary rollers for the canvases, the rollers being replaced by the spindles carrying the sprocket wheels. The object in having the new conveyor on chains is to allow it to run more slackly, in order to lessen the draught of the binder and prevent the slipping or extra tension which occurs with the ordinary rollers and canvases with the variations in the weather. It did its work admirably, and excited not a little interest.

After the cutting of the ordinary plots had been completed, the machines were tried, the one after the other, on a plot which was considerably laid and twisted. Here again the machines accomplished satisfactory work.

Jonathan Middleton. James Hay.
G. R. Glendinning. James D. Park.
George J. Walker.

## Trial of Manure Distributors.

The following prizes for machines for distributing artificial manures were offered, viz.—First prize, £10; Second, £5.

Eighteen machines were entered, and the trial was fixed to take place at Middlefield, Woodside, Aberdeen, on Wednesday, 5th September, the day after the trial of binders.

The following were appointed to act as judges, viz.—Messrs George J. Walker, Portlethen; James Hay, Little Ythsie, Tarves; Ranald Macdonald, Cluny Castle, Aberdeen; and James D. Park, the Society's engineer. Messrs Jonathan Middleton and G. R. Glendinning, the Society's Stewards of Implements, were in charge of the arrangements.

The judges report as follows:—

At the appointed time only one machine appeared—No. 1 in the catalogue, exhibited by Mr William Davidson, Mill of Clola, Mintlaw. In this machine the distribution is effected by a revolving cylinder, twelve inches in diameter, the top of which forms the bottom of a box for holding the manures. The quantity of manure spread is regulated by an eccentric, which is affixed to the inside of one of the driving wheels, and which raises or lowers the bar next the cylinder in the manure box. The machine was tried with superphosphate, nitrate of soda, and dissolved bones. The distribution of the manures was not satisfactory, but the maker explained that the machine was still in the experimental stage.

Another box for the sowing of basic slag was fitted on to this machine. The bottom of this box consists of an iron plate, with round holes, partly covered by a sliding bar for regulating the quantity per acre. The distribution of the basic slag was done in a fairly satisfactory manner. In the whole circumstances, however, the judges do not feel justified in making any award.

Three machines entered by Messrs Ben. Reid & Co. appeared on the ground, but were too late for competition. Two of them were shown at work on the field.

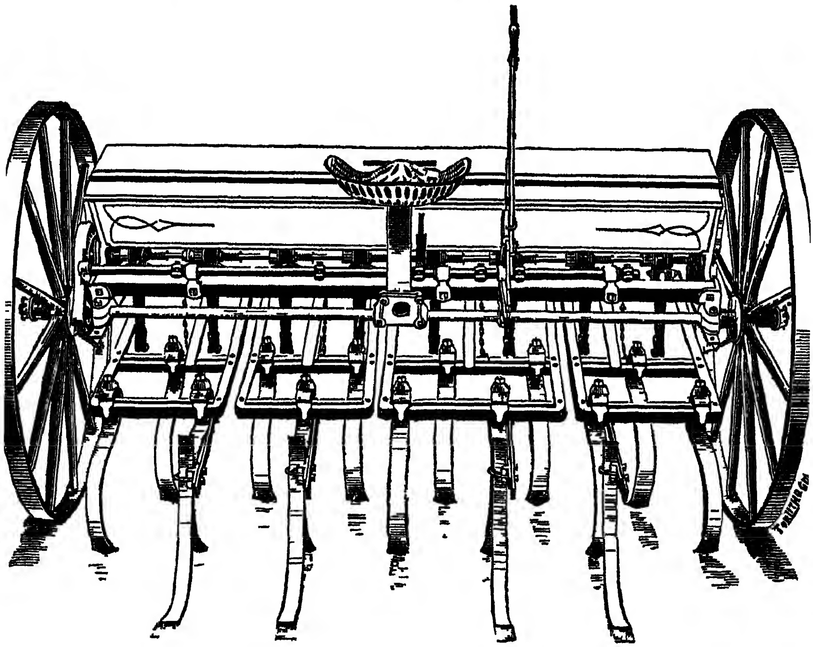
George J. Walker. Ranald Macdonald.
James Hay. James D. Park.

## New Patent Cultivator.

On the recommendation of the Stewards of Implements, it was decided that a new patent cultivator exhibited at the Aberdeen Show by Messrs Massey-Harris Company, Limited, London, should be shown at work in connection with the Society's trial

of manure distributors. This machine was No. 881 in the catalogue of the Aberdeen Show—"Massey-Harris spring-tooth cultivator, 13 tines, with broadcast grain seeding attachment. Price £18, 18s."

That the construction of this machine differs fundamentally from that of other cultivators, will be at once apparent from a glance at the machine itself or at the accompanying illustration of it. This difference consists chiefly in that the tines or teeth,



SPRING-TOOTH CULTIVATOR.

instead of being rigid, are controlled by springs which adjust the action of the tines to the irregularities of the soil. The makers claim that this steel pressure spring device ensures an even pressure, no matter how uneven the ground—so that, although on account of unevenness of the ground surface or obstructions the sections may be bobbing up and down, the pressure, whatever it may be, will always be uniform.

The cultivator was tried on unploughed lea land, and on lea land which had just been ploughed, the soil being moderately light. The trial was watched by the judges of manure distributors, who were impressed with the efficient manner in which the cultivator did its work, both on the lea and the ploughed land; and they consider that it is likely to prove an

extremely useful implement. They think that it will probably be found to be specially suitable for the autumn tillage of stubbles, and that in some parts of the country, with the attached broadcast sower, it may be used for cultivating and sowing barley after turnips eaten by sheep.

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## GENERAL SHOW AT ABERDEEN, 1894.

THE Sixty-seventh Show of the Society, which took place on the Aberdeen Links on the 24th July 1894 and three following days, was the eighth that has been held in the Granite City. The most extensive of the eight, it was by far the most successful.

His Royal Highness the Duke of York, K.G., President of the Society for the year, was present on the second and third days of the Show, presiding at the General Meeting of the members at noon on the second day. His Royal Highness evinced the liveliest interest in the proceedings in the Showyard, and spared no effort to add to the success of the meeting. It was the first official Royal visit paid to the annual Show of the Society, and has been most heartily appreciated by the people of Scotland.

The Show, as formerly, was held on the Links, which the Town Council of Aberdeen were good enough to grant for the occasion. On account of irregularities in the ground, and in view of the Royal visit, it was deemed expedient to design the Showyard upon a somewhat larger scale than usual. The extent enclosed was about 38 acres.

Excepting on the forenoon of the third day, and on the evenings of the second and third days, when showers of rain fell, the weather was highly favourable. How well the Show was attended by the public is indicated by the fact that the drawings at the entrance-gates and parades were even greater than those at the highly successful Show at Edinburgh in 1893.

The collection of live stock, though not unusually large in numbers, was of a very high character. Unfortunately, on account of outbreaks of swine-fever in the district, it was found necessary to exclude swine from the Show.

### *Statistics.*

The number of entries in the various sections is shown in the following tables:—

## Cattle.

| | Bulls. | Cows. | Heifers. | Oxen and Heifers. | Total. |
|---|---|---|---|---|---|
| Shorthorn | 42 | 9 | 26 | .. | 77 |
| Aberdeen-Angus | 23 | 21 | 26 | ... | 70 |
| Galloway | 9 | 6 | 11 | ... | 26 |
| Highland | 24 | 11 | 12 | ... | 47 |
| Ayrshire | 12 | 9 | 14 | ... | 35 |
| Fat cattle | ... | ... | ... | 51 | 51 |
| Extra | 1 | ... | ... | 7 | 8 |
| | 111 | 56 | 89 | 58 | 314 |

## Horses.

| | Stallions. | Entire Colts. | Mares. | Fillies. | Geldings. | Total. |
|---|---|---|---|---|---|---|
| For agricultural purposes | 19 | 51 | 20 | 51 | 23 | 164 |
| Hunters and roadsters | ... | ... | 14 | 10 | 19 | 43 |
| Yearlings, the produce of the Queen's premium stallions | ... | 2 | ... | 7 | 1 | 10 |
| Hackneys | 6 | 5 | 6 | 14 | ... | 31 |
| Ponies | 6 | ... | 24 | .. | 7 | 37 |
| Shetland ponies | 12 | .. | 18 | ... | 2 | 32 |
| Extra horses | 1 | ... | 1 | .. | 2 | 7 |
| Jumping | ... | ... | .. | ... | ... | 25 |
| | 47 | 58 | 83 | 82 | 54 | 349 |

## Sheep.

| | Tups. | Ewes. | Gimmers. | Lambs. | Wethers and Fat Lambs. | Total. |
|---|---|---|---|---|---|---|
| Blackfaced | 39 | 12 | 6 | 2 | ... | 59 |
| Cheviot | 34 | 5 | 6 | ... | ... | 45 |
| Border Leicester | 31 | 1 | 8 | ... | ... | 40 |
| Shropshire | 12 | 2 | 4 | ... | ... | 18 |
| Extra sections | ... | ... | ... | ... | 21 | 21 |
| Extra sheep | ... | 1 | ... | ... | ... | 1 |
| | 116 | 21 | 24 | 2 | 21 | 184 |

SWINE.

| | Boars. | Sows. | Pigs. | Total. |
|---|---|---|---|---|
| Large white breed . . . . . | 3 | 4 | 2 | 9 |
| White breed, other than large . . | 4 | 5 | 4 | 13 |
| Berkshire breed . . . . . | 3 | 4 | 3 | 10 |
| Extra . . . . . . . . | ... | 2 | ... | 2 |
| | 10 | 15 | 9 | 34 |

| | Entries. |
|---|---|
| POULTRY . . . . . . . . . . . | 365 |
| DAIRY PRODUCE— | |
| Butter . . . . . . . . . | 58 |
| HORSE-SHOEING . . . . . . . . . | 34 |
| IMPLEMENTS (183 stands) . . . . . . | 2532 |

The following table gives a comparative view of the display of cattle, horses, sheep, swine, poultry, dairy produce, and implements, of the value of the premiums offered, and of the receipts at the entrance-gates, grand stands, and for catalogues at the Shows which have been held at Aberdeen:—

| Year. | Cattle. | Horses. | Sheep. | Swine. | Poultry. | Dairy Produce. | Butter-making. | Horse-shoeing. | Implements. | Premiums. | Receipts. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1834 . | 188 | 77 | 192 | 58 | ... | 28 | ... | ... | 9 | £627 | £337 |
| 1840 . | 269 | 80 | 126 | 69 | ... | 46 | ... | ... | 30 | 781 | 586 |
| 1847 . | 361 | 105 | 230 | 24 | 102 | 42 | ... | ... | 49 | 920 | 570 |
| 1858 . | 450 | 189 | 590 | 79 | 366 | ... | ... | ... | 802 | 1500 | 1229 |
| 1868 . | 373 | 139 | 632 | 57 | 480 | ... | ... | ... | 1158 | 1600 | 1577 |
| 1876 . | 424 | 227 | 478 | 84 | 520 | ... | ... | ... | 1812 | 2440 | 2899 |
| 1885 . | 385 | 223 | 423 | 11 | 252 | 40 | ... | ... | 1849 | 2368 | 3436 |
| 1894 . | 314 | 324 | 314 | 52* | 364 | 58 | 20 | 34 | 2532 | 2440 | 5136 |

* Not exhibited on account of outbreaks of swine-fever in district.

### *The Duke of York's Medals.*

His Royal Highness the Duke of York was good enough to offer a Bronze Medal of artistic design for the best animal in each of the following sections, viz.:—(1) Shorthorn, (2) Aberdeen-Angus, (3) Galloway, (4) Highland, (5) Ayrshire, (6) Fat Cattle, (7) Clydesdale Stallions, (8) Clydesdale Mares and Fillies, (9) Draught Geldings, (10) Hunters, (11) Roadsters, (12) Hackneys, (13) Ponies, (14) Shetland Ponies, (15) Blackfaced Sheep, (16) Cheviot Sheep, (17) Border Leicesters, (18) Shropshire, (19) Fat Sheep, and (20) Swine. In almost every case

the medals were keenly contested for, and won by animals of outstanding merit. His Royal Highness was graciously pleased to present the medals to the winners at the Grand Stand on the forenoon of the third day of the Show. The ceremony was one of the most interesting events of the meeting, including as it did the display in the ring of the animals for which the medals had been awarded.

*Cattle.*

In respect to average merit, the display of cattle has been rarely excelled. In the Shorthorn classes the improvement over recent years manifested at Edinburgh was well maintained at Aberdeen. This is just what might have been expected in a county that has done much to develop the most valuable properties of the modern Shorthorn. And it was peculiarly fitting that the Duke of York's medal for the best Shorthorn in the yard should have been awarded to the leading Aberdeenshire Shorthorn breeder of the day for a peculiarly typical Aberdeenshire Shorthorn. Mr William Duthie's two-year-old bull, "Pride of Morning" (64,546), which attained this distinction, is a capital specimen of a rent-paying Shorthorn, thick and handsome in form, robust in constitution, and well furnished with muscle and lean flesh. The large number of commendation tickets awarded by the judges testifies to the creditable manner in which every one of the Shorthorn classes was filled.

The Aberdeen-Angus breed, with its foot on its native heath, was expected to make a very strong appearance. Owing chiefly to the recent dispersion of some leading herds, and to the absence of representatives of the Ballindalloch herd, the muster of the breed was not quite so large as at several former Shows. In regard to merit, however, there was certainly no falling off. Indeed, it was the prevailing opinion that a finer display of the northern polls had seldom been seen in any showyard. Her Majesty the Queen's two-year-old heifer, "Gentian of Ballindalloch" (19,258), to which was awarded the Duke of York's medal for the best animal of the breed, was in every way worthy of the distinction, difficult as it was to attain. She was bred at Ballindalloch.

So far from the home of the breed, a large turn-out of Galloway cattle was not expected. The breed, however, was admirably represented in point of merit, Mr John Cunningham winning the Duke of York's medal with an exceedingly handsome yearling heifer bred by Mr James Cunningham, Tarbreoch.

Highland cattle, although not so numerous as at Edinburgh in 1893, made quite an imposing display. The best features of the breed were well represented, Mr Smith's yearling bull,

which won the Duke of York's medal, being a well-formed animal of great promise, bred by himself.

Ayrshires were few in number but of very high average merit. Mr Alex. Cross won the Duke of York's medal with a very fine cow of his own breeding.

In a county so famous as Aberdeenshire for cattle-feeding, it was appropriate that classes should be provided for fat cattle. These classes were on the whole well filled, the animals shown being of a thoroughly useful character.

### *Clydesdales.*

Since the last preceding Show of the Society at Aberdeen, the breeding of Clydesdale horses has increased considerably in the north of Scotland. Naturally enough, therefore, the classes of Clydesdale horses formed an exceptionally strong and attractive feature of the Show. The two stallion classes were well filled, including as they did several animals well known as excellent representatives of the breed. Still stronger perhaps were the two-year-old colts, and amongst the yearling colts there were also some animals of high promise. Mr Andrew Montgomery's four-year-old "Sir Everard" horse "Baron's Pride" (9122), of Messrs R. & J. Findlay's breeding, was a worthy winner of the Duke of York's medal for the best Clydesdale stallion or colt.

In a very fine collection of Clydesdale mares and fillies, the chief object of interest was Mr Gilmour's celebrated mare "Moss Rose" (6203), which had at the Aberdeen Show in 1886 won the first prize in the dry mare class, and which after an interval of nine years appeared in such good form that again she triumphed over all her opponents. She was not eligible for the Duke of York's medal for the best Clydesdale mare or filly in the ordinary classes, which therefore went to her well-known daughter "Montrave Maid" (11,786). There were seventeen entries in each of the three filly classes, and very good as a lot they were.

The classes of draught geldings introduced this year were not quite so large as was expected. In the three classes there were only twenty-three entries. Several of the animals, however, were of high merit.

Hunters and roadsters were few in number, but of a satisfactory character. The hackney classes bore evidence of the growing interest in this very useful race of stock in Scotland. The class of stallions and the young filly classes were especially well filled. The pony section was an exceptionally interesting one, more particularly the classes of Shetland ponies.

As at Edinburgh, the jumping competitions were conspicu-

ROYAL PAVILION, ABERLEEN SHOW. 1894.

ously successful. It was again abundantly shown that this feature in the proceedings was highly popular with all classes of visitors.

### *Sheep, &c.*

The classes of sheep, with few exceptions, were well filled, and in regard to merit the leading breeds were all very strongly represented. The sheep which won the Duke of York's medals for Mr Howatson of Glenbuck; Mr John Elliot, Hindhope; Mr T. Clark, Oldhamstocks; Mr D. Buttar, Corston; and Mr John Gilmour of Montrave, made a very fine display when drawn into the ring for the presentation of the medals.

As already mentioned, swine had to be excluded from the Show on account of outbreaks of swine-fever in the district. There was a good collection of poultry, and a small but creditable display of butter.

Much interest was manifested in the butter-making competitions, as well as in the working dairy conducted for the Society by the Scottish Dairy Institute, Kilmarnock. Mr R. J. Drummond superintended the dairy, and Miss C. Shirley's lectures and demonstrations on butter-making were highly appreciated by large audiences.

The display in the implements department was by far the largest at any of the Society's Shows at Aberdeen, and it is gratifying to learn that in this section of the Showyard business was very active. The Stewards recommended that a new patent cultivator (No. 881 in the Catalogue), exhibited by Messrs Massey-Harris Coy., Ltd., London, be tried under the auspices of the Society. The recommendation was approved by the Directors, and the cultivator was tried, with satisfactory results, in connection with the Society's Machinery Trials at Woodside in September.

### *Royal Pavilion.*

An attractive and popular feature in the Showyard was the Royal Pavilion erected for the use of the Royal President. It occupied a commanding position upon an eminence overlooking the greater part of the Showyard. As a building of the kind it was unique, and so deserves more than passing notice.

From designs prepared by the Society's officials it was constructed in wood by the Society's contractor, Mr James Farquhar, Brownhill Place, Aberdeen, who was heartily congratulated upon the character of his handiwork. The building was intended to represent a rustic shooting-lodge. The front, as will be seen from the accompanying illustration, was in the form of three gables, the centre division being shaped as a

balcony with verandah, constructed of natural American pine, and ornamented with deers' heads sent from Glenmuick House by Sir Allan Mackenzie, Bart.

Leading off the entrance-hall to the right was a reception-room, 20 feet by 14 feet, and off that again a retiring-room for his Royal Highness. To the left of the entrance-hall was the dining-hall, 50 feet by 20 feet, and right back from the entrance was a ladies' room, 10 feet by 20.

The furnishing of the Pavilion was intrusted to Messrs J. & A. Ogilvie, cabinetmakers, Union Street, Aberdeen, who were highly complimented upon the exquisitely handsome and tasteful manner in which they furnished and decorated the various compartments. The furniture was of the early eighteenth century style, a special feature being the chairs, which, from the design of an ancient chair in the possession of the firm, were made for the occasion by the Messrs Ogilvie, and will be henceforth known as the Duke of York chair.

The ground in front of the Pavilion was beautifully laid out by Messrs Ben. Reid & Co., Royal seedsmen, Aberdeen. Four weeks before the opening of the Show the site of the Pavilion was a veritable bank of blowing sand. In that short space of time the ground in front was transformed by the Messrs Reid into a velvety lawn, displaying a thick coating of rich fresh grasses, the seeds of which had been sown just twenty-one days before the first day of the Show. Shaped artistically in the form of a crown, this grassy slope was bordered on each side by a collection of rare and graceful coniferous and evergreen trees and shrubs from the nurseries of Messrs Reid. Vases filled with *Agave Americana variegata* and flowering plants were arranged in front of the Pavilion, and on the edge of a terrace formed in the slope.

The grounds were enclosed by a handsome continuous iron bar fence, specially made for the occasion by Messrs Ben. Reid & Co., Bon Accord Works, Aberdeen. The wrought-iron entrance-gate, in itself neat and unassuming, had on either side a highly ornamental wrought-iron panel designed and made at the Bon Accord Works.

On the afternoon of the third day, just before the Duke of York left the Showyard, Mr Alex. Ogilvie, of Messrs J. & A. Ogilvie, Mr Alex. Hay, of Messrs Ben. Reid & Co., Royal seedsmen, and Mr William Anderson, of Messrs Ben. Reid & Co., Bon Accord Works, were presented to His Royal Highness, who expressed his appreciation of the manner in which the Pavilion had been prepared and fitted for his comfort.

# PREMIUMS AWARDED BY THE SOCIETY IN 1894

## I.—ABERDEEN SHOW

*24th, 25th, 26th, and 27th July 1894*

ABBREVIATIONS.—V. H. C., *Very Highly Commended.* H. C., *Highly Commended.* C., *Commended.*

### CATTLE

#### SHORTHORN.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Shorthorn in Classes* 1 *to* 6.

William Duthie, Collynie, Tarves, "Pride of Morning" (64,546).

*Best Bull of any age in Classes* 1, 2, *and* 3—£20, given by the Shorthorn Society.

William Duthie, Collynie, Tarves, "Pride of Morning" (64,546).

*Breeder of best Bull of any age in Classes* 1, 2, *and* 3—Silver Medal

William Duthie, Collynie, Tarves.

CLASS 1. BULL, calved before 1st January 1892.—Premiums, £15, £10, and £5.

1st. William Graham, Edengrove, Penrith, "Fairy King" (62,570).
2d. Thomas Lambert, Elrington Hall, Hexham, "Nonsuch."
3d. James Milne, jun., Nether Cairnhill, Muchalls, "Waverley."
V.H.C. George Inglis, Newmore, Invergordon, "Just in Time" (62,762).
H.C. D. C. Bruce, Broadland, Huntly, "Goldsmith" (57,402).
C. Wm. Peterkin, Dunglass, Conon Bridge, "Chamberlain" (60,461).

CLASS 2. BULL, calved in 1892.—Premiums, £15, £10, and £5.

1st. William Duthie, Collynie, Tarves, "Pride of Morning" (64,546).
2d. John Gordon Smith, Minmore, Glenlivet, "Goldspur" (64,107).
3d. John Gordon Smith, Minmore, Glenlivet, "Faugh-a-Ballagh."
V.H.C. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, "Sittyton Seal" (64,866).
H.C. D. C. Bruce, Broadland, Huntly, "Sir Arthur" (64,833).
C. James Durno, Jackstown, Rothienorman, "Lord Douglas" (64,313).

CLASS 3. BULL, calved in 1893.—Premiums, £12, £8, and £4.

1st. Lord Polwarth, Mertoun House, St Boswells, "Imperial Gold."
2d. John Handley, Green Head, Milnthorpe, Westmoreland, "Duke of York."
3d. George Harrison, Underpark, Lealholm, Grosmont, Yorkshire, "Champion Cup."
V.H.C. John Gilmour of Lundin and Montrave, Leven, Fife, "Braw Duke."
H.C. James M'William, Stoneytown, Keith, "Surprise."
C. Arthur W. Law, Mains of Sanquhar, Forres, N.B., "Prince of Hell."

CLASS 4. COW, of any age.—Premiums, £12, £8, and £4.

1st. George Harrison, Underpark, Lealholm, Grosmont, Yorkshire, "Warfare."
2d. James Carnegie, Ayton Hill, Newburgh-on-Tay, "Rock Cistus."
3d. Lord Polwarth, Mertoun House, St Boswells, "Heroine."
V.H.C. Robert Turner, Cairnton of Boyndie, Portsoy, "Mayflower."
H.C. Lord Polwarth, Mertoun House, St Boswells, "Wave Mist."

CLASS 5. HEIFER, calved in 1892.—Premiums, £10, £5, and £3.

1st. Alexander M. Gordon, of Newton, Insch, "Buttermilk."
2d. Lord Polwarth, Mertoun House, St Boswells, "Bridal Robe."
3d. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, "Queen of Dalmeny."
V.H.C. Lord Polwarth, Mertoun House, St Boswells, "Windsor's Queen."
H.C. George Inglis, Newmore, Invergordon, "Lady Underley 9th."

CLASS 6. HEIFER, calved in 1893.—Premiums, £10, £5, and £3.

1st. George Harrison, Underpark, Lealholm, Grosmont, Yorkshire, "Blanche."
2d. Arthur W. Law, Mains of Sanquhar, Forres, N.B., "Graceful 3d."
3d. George Harrison, Underpark, Lealholm, Grosmont, Yorkshire, "Gratia."
V.H.C. James M'William, Stoneytown, Keith, "Bouquet."
H.C. Alexander Leslie of Braco, Keith, "Morna."
C. J. Douglas Fletcher, of Rosehaugh, Avoch, N.B., "Kirklevington Daisy."

## ABERDEEN-ANGUS.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Aberdeen-Angus in Classes 7 to 13.*

Her Majesty the Queen, Abergeldie Mains, Ballater, "Gentian of Ballindalloch," (19,258).

*Best Bull of any age in Classes* 7, 8, *and* 9—Ballindalloch Challenge Cup, value £50, given by Mr Macpherson Grant of Drumduan. The Cup shall be held by the winner for one year, and shall become the property of the Exhibitor who shall win it five times, not necessarily in succession.

Patrick Chalmers, Aldbar Castle, Brechin, "Enthusiast of Ballindalloch" (8289).

*Best Bull of any age in Classes* 7, 8, *and* 9—Gold Medal, value £8, 10s., given by the Polled Cattle Society.

Patrick Chalmers, Aldbar Castle, Brechin, "Enthusiast of Ballindalloch" (8289).

*Breeder of best Bull of any age in Classes* 7, 8, *and* 9—Silver Medal.

Sir George Macpherson Grant, Bart., Ballindalloch Castle, Ballindalloch.

CLASS 7. BULL, calved before 1st December 1891.—Premiums, £15, £10, and £5.

1st. Patrick Chalmers, Aldbar Castle, Brechin, "Enthusiast of Ballindalloch" (8289).
2d. Fred. Crisp, White House Stud Farm, New Southgate, London, N., "Gilderoy" (9208).
3d. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, "Marquis of Moray" (9387).
V.H.C. Marquis of Huntly, Aboyne Castle, Aboyne, "Elf Prince" (9116).
H.C. S. Anketell Jones, Springfield, Waterford, "Gay Knight" (8351).
C. Marquis of Huntly, Aboyne Castle, Aboyne, "Privateer" (9550).

CLASS 8. BULL, calved on or after 1st December 1891.—Premiums, £15, £10, and £5.

1st. George Smith Grant, Auchorachan, Glenlivet, Ballindalloch, "Equestrian" (9953).
2d. John Grant, Advie Mains, Advie, "Provost."
3d. George Wilken, Waterside of Forbes, Vale of Alford, "Miclas" (10,255).
V.H.C. A. C. Pirie, Craibstone Mains, Auchmill, "Nachrichten" (10,286).

CLASS 9. BULL, calved on or after 1st December 1892.—
Premiums, £12, £8, and £4.

1st. George Smith Grant, Auchorachan, Glenlivet, Ballindalloch, "Boaz of Ballindalloch" (10,672).
2d. The Countess Dowager of Seafield, Home Farm, Cullen House, Cullen, "Bernadotte" (10,648).
3d. Captain Edward Fraser, of Williamston, Insch, Aberdeenshire, "Mayor of Auchorachan" (11,071).
V.H.C. Her Majesty the Queen, Abergeldie Mains, Ballater, "Eulenberg" (10,825).
H.C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis, "Minstrel" (11,088).
C. Alexander Strachan, Wester Fowlis, Alford, "The Meadow King" (11,345).

*Best Cow of any age in Classes* 10 *and* 11—Ballindalloch Challenge Cup, value £50, given by Mr Macpherson Grant of Drumduan. The Cup shall be held by the winner for one year, and shall become the property of the Exhibitor who shall win it five times, not necessarily in succession.

George Smith Grant, Auchorachan, Glenlivet, Ballindalloch, "Legend" (16,518).

*Breeder of best Cow of any age in Classes* 10 *and* 11—Silver Medal.

George Smith Grant, Auchorachan, Glenlivet, Ballindalloch.

*Best Female Animal in Classes* 10, 11, 12, *and* 13—Gold Medal, value £8, 10s., given by the Polled Cattle Society.

Her Majesty the Queen, Abergeldie Mains, Ballater, "Gentian of Ballindalloch" (19,258).

*Best Heifer in Classes* 12 *and* 13—£10 given by the late Mrs Morison Duncan of Naughton.

Her Majesty the Queen, Abergeldie Mains, Ballater, "Gentian of Ballindalloch" (19,258).

CLASS 10. COW, calved before 1st December 1890.—Premiums, £12, £8, and £4.

1st. George Smith Grant, Auchorachan, Glenlivet, Ballindalloch, "Legend" (16,518).
2d. Her Majesty the Queen, Abergeldie Mains, Ballater, "Eurya" (13,708).
3d. George Bruce, Tochineal, Cullen, "Caroline of Knockie Mill" (14,051).
V.H.C. Robert Forbes, Woodhead, Kinloss, Forres, "Queen 2d of Lynemore" (17,835).
H.C. Thomas Smith, Powrie, Dundee, "May 18th" (14,287).
C. William Wilson, Coynachie and Drumfergue, Gartly, "Lucy of Conachie B 2d" (11,965).

CLASS 11. COW, calved on or after 1st December 1890,—Premiums, £12, £8, and £4, given by Mr Macpherson Grant of Drumduan.

1st. Thomas Smith, Powrie, Dundee, "Pride of Powrie 5th" (19,819).
2d. The Marquis of Huntly, Aboyne Castle, Aboyne, "St Catherine" (18,063).
3d. Charles P. Sykes, West Ella, Hull, East Yorkshire, "Witch of Endor 19th" (18,526).
V.H.C. Thomas Smith, Powrie, Dundee, "Witch of Endor 15th" (18,522).
H.C. Thomas Smith, Powrie, Dundee, "Ruby 26th of Powrie" (18,521).

CLASS 12. HEIFER, calved on or after 1st December 1891.—
Premiums, £10, £5, and £3.

1st. Her Majesty the Queen, Abergeldie Mains, Ballater, "Gentian of Ballindalloch" (19,258).
2d. John Grant, Advie Mains, Advie, "Queen of Advie."
3d. The Marquis of Huntly, Aboyne Castle, Aboyne, "Versatile" (19,371).
V.H.C. The Earl of Airlie, Cortachy Castle Home Farm, Kirriemuir, "Naughty Girl" (18,780).
H.C. Her Majesty the Queen, Abergeldie Mains, Ballater, "Princess Irene 4th."
C. The Marquis of Huntly, Aboyne Castle, Aboyne, "Tiddle-de-dee" (19,368).

CLASS 13. HEIFER, calved on or after 1st December 1892.—Premiums, £10, £5, and £3.

1st. Her Majesty the Queen, Abergeldie Mains, Ballater, "Lorna Doone."
2d. The Countess Dowager of Seafield, Home Farm, Cullen House, Cullen, "Cullen Coquette" (20,995).
3d. James Walker, Westside of Brux, Mossat, "Missie 12th of Westside."
V.H.C. The Marquis of Huntly, Aboyne Castle, Aboyne, "St Barbara" (20,651).
H.C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis, "Melody of Glamis" (21,145).
C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis, "Balm of Glamis" (21,138).

## GALLOWAY.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Galloway in Classes* 14 *to* 19.

James Cunningham, Tarbreoch, Dalbeattie, "Madonna 2d of Tarbreoch" (11,056).

*Breeder of best Bull of any age in Classes* 14, 15, *and* 16—Silver Medal.

James Cunningham, Tarbreoch, Dalbeattie.

CLASS 14. BULL, calved before 1st January 1892.—Premiums, £15, £10, and £5.

1st. The Duke of Buccleuch and Queensberry, K.T., Drumlanrig Castle, Thornhill, "Baron Wedholme of Drumlanrig" (5912).
2d. Thomas Biggar & Sons, Chapelton, Dalbeattie, "Viking" (5021).
3d. The Duke of Buccleuch and Queensberry, K.T., Drumlanrig Castle, Thornhill, "Bosphorus" (4693).

CLASS 15. BULL, calved in 1892.—Premiums, £15, £10, and £5.

1st. William Parkin-Moore, Whitehall, Mealsgate, Carlisle, "Macdougall 3d of Tarbreoch" (5840).
2d. Christopher Graham, Harelawhill, Canonbie, "The Gladiator 2d" (5830).

CLASS 16. BULL, calved in 1893.—Premiums, £12, £8, and £4.

1st. Christopher Graham, Harelawhill, Canonbie, "The Pathfinder 3d" (5991).
2d. Christopher Graham, Harelawhill, Canonbie, "Indian Emperor" (5910).
3d. John Cunningham, Durhamhill, Dalbeattie, "Scottish Knight of Durhamhill" (5924).

CLASS 17. COW, of any age.—Premiums, £12, £8, and £4.

1st. James Cunningham, Tarbreoch, Dalbeattie, "Madonna 2d of Tarbreoch" (11,056).
2d. James Cunningham, Tarbreoch, Dalbeattie, "Bell 3d of Drumhumphry" (10,633).
3d. The Countess of Carlisle, Naworth Castle, Brampton, "Lady Queen 3d of Tarbreoch" (11,611).
V.H.C. Leonard Pilkington, Cavens, Dumfries, "Isabel of Tarbreoch" (12,552).

CLASS 18. HEIFER, calved in 1892.—Premiums, £10, £5, and £3.

1st. Leonard Pilkington, Cavens, Dumfries, "Mabel of Castlemilk" (12,950).
2d. The Duke of Buccleuch and Queensberry, K.T., Drumlanrig Castle, Thornhill, "Hannah 10th of Drumlanrig" (12,918).
3d. The Countess of Carlisle, Naworth Castle, Brampton, Cumberland, "Vaudeville 4th of Naworth" (13,172).
V.H.C. The Countess of Carlisle, Naworth Castle, Brampton, Cumberland, "Primrose 2d of Drumlanrig" (12,928).

CLASS 19. HEIFER, calved in 1893.—Premiums, £10, £5, and £3.

1st. John Cunningham, Durhamhill, Dalbeattie, "Dora of Durhamhill" (13,350).
2d. The Duke of Buccleuch and Queensberry, K.T., Drumlanrig Castle, Thornhill, "Pride 7th of Drumlanrig" (13,407).
3d. Leonard Pilkington, Cavens, Dumfries, "Tidy of Cavens" (13,454).
V.H.C. The Duke of Buccleuch and Queensberry, K.T., Drumlanrig Castle, Thornhill, "Peeress 14th of Drumlanrig" (13,411).
H.C. The Countess of Carlisle, Naworth Castle, Brampton, Cumberland, "Snowdrop of Naworth" (13,441).

## HIGHLAND.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Highland in Classes 20 to 25.*

Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Valentine 11th."

*Breeder of best Bull of any age in Classes* 20, 21, *and* 22—Silver Medal.

Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire.

CLASS 20. BULL, calved before 1st January 1892.—Premiums, £15, £10, and £5.

1st. John Stewart of Ensay, Obbe, "An Gaidheal Gasda" (969).
2d. The Duke of Atholl, K.T., Blair Castle, Blair Atholl, "Adhollach" (960).
3d. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Victor 7th" (1067).
V.H.C. The Earl of Southesk, K.T., Kinnaird Castle, Brechin, "Duke of Berwick" (877).
H.C. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Bhaltair" (851).
C. M. & E. MacRae, Mains of Kinbeachie, Conon Bridge, "An Gaisgeach" (971).

CLASS 21. BULL, calved in 1892.—Premiums, £15, £10, and £5.

1st. John Stewart of Ensay, Obbe, "An-t-Oganach."
2d. The Marquis of Breadalbane, K.G., Taymouth Castle, Aberfeldy, "Young Rossie."
3d. D. A. Stewart, Scorrybreck, Portree, "An Gille Math."
V.H.C. Donald Graham, C.I.E., of Airthrey, Airthrey Castle, Bridge of Allan, "Achnachard" (959).

CLASS 22. BULL, calved in 1893.—Premiums, £12, £8, and £4.

1st. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Valentine 11th."
2d. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Victor 11th."
3d. The Mackintosh of Mackintosh, Moy Hall, Inverness, "Ixion."
V.H.C. J. R. Campbell, Shinness, Lairg, Sutherland, "Rob Don."
H.C. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Prionnsa a Buidhe."
C. Alexander Macdonald, Nether Largie, Lochgilphead, "Alastair Riabhach."

CLASS 23. COW, of any age.—Premiums, £12, £8, and £4.

1st. The Duke of Atholl, K.T., Blair Castle, Blair Atholl, "Beauty 1st of Atholl" (2550).
2d. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Phroiseag 4th of Ardtornish" (2275).
3d. J. R. Campbell, Shinness, Lairg, Sutherland, "Mairi Ruadh of Sutherland" (2909).
V.H.C. The Earl of Southesk, K.T., Kinnaird Castle, Brechin, "Delia Emily" (1259).
H.C. Sir Reginald A. E. Cathcart, Bart., Cluny Castle, Aberdeen, "Fionnaghal."
C. The Countess Dowager of Seafield, Castle Grant, Grantown, "Maggie of Seafield" (1702).

CLASS 24. HEIFER, calved in 1891.—Premiums, £10, £5, and £3.

1st. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Sgiathach 6th" (2929).
2d. J. R. Campbell, Shinness, Lairg, Sutherland, "Bessy."
3d. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Ealasaid."
V.H.C. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Nora O'g."
H.C. The Earl of Cawdor, Cawdor Castle, Nairn, "Highland Lassie."
C. The Countess Dowager of Seafield, Castle Grant, Grantown, "Freuchie 2d" (2916).

CLASS 25. HEIFER, calved in 1892.—Premiums, £10, £5, and £3.

1st. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Proiseag 4th."
2d. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Ruadh Bheag."
3d. Thomas Valentine Smith, Ardtornish, Morvern, Argyllshire, "Cruineag 3d."
V.H.C. The Countess-Dowager of Seafield, Castle Grant, Grantown, "Aunt Margaret."
H.C. Colonel Malcolm, C.B., of Poltalloch, Poltalloch, Lochgilphead, "Corcan."
C. The Earl of Cawdor, Cawdor Castle, Nairn.

AYRSHIRE.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Ayrshire in Classes* 26 *to* 32.

Alexander Cross, Knockdon, Maybole, "Brisbane" (6384).
*Reserve.* Andrew Mitchell, Barcheskie, Kirkcudbright, "Rosebud."

*Breeder of best Bull of any age in Classes* 26, 27, *and* 28—Silver Medal.

Sir Mark J. Stewart, Bart., M.P., Southwick, Dumfries.

CLASS 26. BULL, calved before 1st January 1892.—Premiums, £15, £10, and £5.

1st. Sir Mark J. Stewart, Bart., M.P., Southwick, Dumfries, "Hover's Heir" (2690).
2d. Hugh Drummond, Craighead, Mauchline, "Duke of Mauchline" (2680).

CLASS 27. BULL, calved in 1892.—Premiums, £12, £8, and £4.

1st. Robert Wardrop, Garlaff, Cumnock, "Blood for Ever" (2659).
2d. Andrew Mitchell, Barcheskie, Kirkcudbright, "Duke of York."
3d. Leonard Pilkington, Cavens, Dumfries, "Field Marshal."

CLASS 28. BULL, calved in 1893.—Premiums, £8, £5, and £3.

1st. Robert Montgomerie, Lessnessock, Ochiltree, "Royal Macgregor."
2d. Sir Mark J. Stewart, Bart., M.P., Southwick, Dumfries, "First Choice."
3d. Hugh Drummond, Craighead, Mauchline, "Paymaster."
H.C. Robert Wardrop, Garlaff, Cumnock, "King of the Flynns" (2890).
C. Robert Montgomerie, Lessnessock, Ochiltree, "Baron Stewart."

CLASS 29. COW (in Milk), of any age.—Premiums, £10, £7, and £3.

1st. James Wilson, Boghall, Houston, "Trim 6th" (8802).
2d. Andrew Mitchell, Barcheskie, Kirkcudbright, "Lottery."
3d. Fairfield Farming Co., Ltd., Fairfield, Kippen Station, Stirlingshire, "Cherry 7th of Castlehill" (8804).

CLASS 30. COW, of any age, in Calf, or Heifer calved in 1891 in Calf and due to calve within one month of the first day of the Show.—Premiums, £10, £7, and £3.

1st. Alexander Cross, Knockdon, Maybole, "Brisbane" (6384).
2d. Alexander Cross, Knockdon, Maybole, "Look On" (6773).
3d. Robert Wilson, Manswraes, Bridge of Weir, "Blackie."
V.H.C. Fairfield Farming Co., Ltd., Fairfield, Kippen Station, Stirlingshire, "Fairfield Snowdrop."
H.C. Robert Wilson, Manswraes, Bridge of Weir, "Melrose 3d."

CLASS 31. HEIFER, calved in 1892.—Premiums, £10, £5, and £3.

1st. Andrew Mitchell, Barcheskie, Kirkcudbright, "May Mischief."
2d. Hugh Drummond, Craighead, Mauchline, "Clementine" (8859).
3d. Leonard Pilkington, Cavens, Dumfries, "Monica" (8500).
H.C. Sir Mark J. Stewart, Bart., M.P., Southwick, Dumfries, "Bess 5th of Southwick."

CLASS 32. HEIFER, calved in 1893.—Premiums, £8, £5, and £3.

1st. Andrew Mitchell, Barcheskie, Kirkcudbright, "Rosebud."
2d. Sir Mark J. Stewart, Bart., M.P., Southwick, Dumfries, "Princess 6th."
3d. Robert Montgomerie, Lessnessock, Ochiltree, "Snowdrop 3d."
V.H.C. Leonard Pilkington, Cavens, Dumfries, "Daisy Bell."
H.C. Robert Wardrop, Garlaff, Cumnock, "Lady Louisa" (8665).
C. Andrew Mitchell, Barcheskie, Kirkcudbright, "Roseleaf."

## FAT CATTLE.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Fat Animal in Classes 33 to 38.*

The Countess-Dowager of Seafield, Home Farm, Cullen House, Cullen, Aberdeen-Angus, "Inchcorsie Kate" (19,782).

CLASS 33. ABERDEEN-ANGUS or GALLOWAY OX, calved after 1st December 1891.—Premiums, £5 and £2.

The Earl of Rosebery, Dalmeny Park, Linlithgowshire, Aberdeen-Angus.

CLASS 34. ABERDEEN-ANGUS or GALLOWAY OX, calved after 1st December 1892.—Premiums, £5 and £2.

1st. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, Aberdeen-Angus.
2d. George Bruce, Tochineal, Cullen, Aberdeen-Angus.
V.H.C. George Bruce, Tochineal, Cullen, Aberdeen-Angus.

CLASS 35. OX, of any other Pure Breed or Cross, calved after 1st December 1891.—Premiums, £5 and £2.

1st. Robert Turner, Cairnton of Boyndie, Portsoy, Cross, "Roan Prince."
2d. John Gilmour, of Lundin and Montrave, Leven, Fife, Cross.
V.H.C. John Gilmour, of Lundin and Montrave, Leven, Fife, Cross.
H.C. D. C. Bruce, Byres Farm, Fochabers, Shorthorn.
H.C. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, Cross.
C. A. C. Pirie, Craibstone Mains, Auchmill, Cross.
C. John Gordon Smith, Minmore, Glenlivet, Shorthorn.

CLASS 36. OX, of any other Pure Breed or Cross, calved after 1st December 1892.—Premiums, £5 and £2.

1st. John Ross, Meikle Tarrel, Fearn, Cross.
2d. John Ross, Meikle Tarrel, Fearn, Cross.
V.H.C. The Earl of Rosebery, Dalmeny Park, Linlithgowshire, Cross.
H.C. J. Douglas Fletcher, Avoch, N.B., Shorthorn, "Victory."
H.C. John Gordon Smith, Minmore, Glenlivet, Shorthorn, "Mak' Siccar."
C. The Earl of Aberdeen, the Mains, Haddo House, Aberdeen, Cross.

CLASS 37. HEIFER, of any Pure Breed or Cross, calved after 1st December 1891.—Premiums, £5 and £2.

1st. The Countess-Dowager of Seafield, Home Farm, Cullen House, Cullen, Aberdeen-Angus, "Inchcorsie Kate" (19,782).
2d. C. M. Cameron, Balnakyle, Munlochy, Shorthorn, "Dandy 8th."
V.H.C. George Bruce, Tochineal, Cullen, N.B., Polled, "Princess May."
H.C. R. Copland, Milton Ardlethen, Ellon, Cross, "Queen of Spades."
C. Henry F. Begg of Tillyfour, 17 Weighhouse Square, Aberdeen, Cross.

CLASS 38. HEIFER, of any Pure Breed or Cross, calved after 1st December 1892.—Premiums, £5 and £2.

1st. John Ross, Meikle Tarrel, Fearn, Cross.
2d. John Ross, Meikle Tarrel, Fearn, Cross.
H.C. R. Copland, Milton, Ardlethen, Ellon, Cross, "Miss Brydon."
C. James Milne, jun., Nether Cairnhill, Muchalls, Cross, "Princess May."

## EXTRA CATTLE.

The following were Very Highly Commended and Medium Gold Medals awarded:—

Alexander Strachan, Wester Fowlis, Alford, Aberdeen-Angus Bull, "Fitzlyon" (6056).
James Grant, Glen Grant, Rothes, Highland Ox, "Captain."
The Countess-Dowager of Seafield, Castle Grant, Grantown, Highland Heifer, "Jane."

The following were Highly Commended and Minor Gold Medals awarded:—

James Grant, Glen Grant, Rothes, Highland Ox, "Colonel."
The Countess-Dowager of Seafield, Castle Grant, Grantown, Highland Ox, "Kenny."

The following were Commended and Silver Medals awarded :—

Sir Reginald A. E. Cathcart, Bart., Cluny Castle, Aberdeen, Highland Ox, "Gille Dubh."
William Pyper of Hillhead, Aberdeen, Highland Ox, "Napoleon."
William Pyper of Hillhead, Aberdeen, Highland Ox, "Wellington."

## HORSES

### FOR AGRICULTURAL PURPOSES.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Clyesdale Stallion in Classes* 39 *to* 42.

Andrew & William Montgomery, Nether Hall and Banks, Kirkcudbright, "Baron's Pride" (9122).

*Best Stallion in Classes* 39 *to* 42—Champion Premium of £10, given by Mr Lockhart, Mains of Airies.

Andrew & William Montgomery, Nether Hall and Banks, Kirkcudbright, "Baron's Pride" (9122).

*Breeder of best Male Animal of any age in Classes* 39 *to* 42—Silver Medal.

R. & J. Findlay, Springhill, Baillieston.

CLASS 39. STALLION, foaled before 1st January 1891.—Premiums, £15, £12, £8, and £4.

1st. Andrew & William Montgomery, Nether Hall and Banks, Kirkcudbright, "Baron's Pride" (9122).
2d. Matthew Marshall, Bridgebank, Stranraer, "Prince of Garthland."
3d. J. Douglas Fletcher of Rosehaugh, Avoch, N.B., "Prince Albert of Rosehaugh" (9357).
4th. Robert Spittal, Tollcross, "Summil."
V.H.C. W. S. Park, Hatton, Bishopton, "Gallant Poteath" (8638).
H.C. Alexander M'Robbie, Sunnyside, Aberdeen, "Prince Stephen" (9363).
C. William Graham, Edengrove, Penrith, "Sir Harry" (9411).

CLASS 40. ENTIRE COLT, foaled in 1891.—Premiums, £15, £12, £8, and £4.

1st. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, "Holyrood" (9546).
2d. W. S. Park, Hatton, Bishopton, "Prince of Erskine" (9647).
3d. R. C. Macfarlane, Greenburn, by Stirling, "Gold Mine" (9540).
4th. Andrew & William Montgomery, Nether Hall and Banks, Kirkcudbright, "MacAndrew."
V.H.C. Alexander Scott, Berry Yards Farm, Greenock, "Prince of Fortune" (9826).
H.C. Hon. Henry J. Scott, Brotherstone, St Boswells, "Newbattle" (late "Fergusson," 9526).
C. Colonel Stirling of Kippendavie, Kippenross Home Farm, Dunblane, "Prince of Fife" (9648).

CLASS 41. ENTIRE COLT, foaled in 1892.—Premiums, £15, £10, £6, and £3.

1st. Andrew & William Montgomery, Nether Hall and Banks, Kirkcudbright, "Maceachran" (9792).
2d. William Clark, Netherlea, Cathcart, "Royal Gartly" (9844).
3d. Leonard Pilkington, Cavens, Dumfries, "Royal Standard."
4th. William Park, Brunstane, Portobello, "Prince of Brunstane."
V.H.C. P. & W. Crawford, Eastfield House, Dumfries.
H.C. David Riddell, Blackhall, Paisley.
C. A. E. M'Robbie, Sunnyside, Aberdeen, "Rosario."

CLASS 42. ENTIRE COLT, foaled in 1893.—Premiums, £12, £7, £4, and £2.

1st. David Riddell, Blackhall, Paisley.
2d. Mrs Lamont, Killellan, Toward, "Knight of Cowal."

3d. P. & W. Crawford, Eastfield House, Dumfries, "The Scott."
4th. James Kilpatrick, Craigie Mains, Kilmarnock, "Prince of Caledonia."
V.H.C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.
H.C. David Dow, Balmanno, Bridge of Earn.
C. W. H. Lumsden, Balmedie, Aberdeen, "Balmedie Sage."

*H.R.H. THE DUKE OF YORK'S MEDAL for best Clydesdale Mare or Filly in Classes* 43 *to* 47.

John Gilmour, Montrave, Leven, Fife, "Montrave Maud" (11,786).

*Best Mare or Filly registered in the Clydesdale Stud-Book*—Cawdor Challenge Cup, value 50 guineas, given by the Clydesdale Horse Society. The Cup must be won three times by an Exhibitor (but not necessarily in consecutive years or with the same animal) before it becomes his absolute property.

John Gilmour, Montrave, Leven, Clydesdale Mare, "Moss Rose" (6203).

CLASS 43. MARE, of any age, with Foal at foot.—
Premiums, £15, £10, £5, and £3.

1st. Leonard Pilkington, Cavens, Dumfries, "Queen of the Roses."
2d. Colonel Stirling, of Kippendavie, Kippenross Home Farm, Dunblane, "Brenda of Kippendavie" (12,002).
3d. G. & W. Ferguson, Lumphart, Old Meldrum, "Lady Dora."
4th. George Bean, Inverurie, "Golden Queen."

CLASS 44. YELD MARE, foaled before 1st January 1891.—
Premiums, £10, £6, £3, and £2.

1st. John Gilmour, Montrave, Leven, Fife, "Montrave Maud" (11,786).
2d. David Mitchell, Millfield, Polmont, "Maritana."
3d. W. H. Lumsden, Balmedie, Aberdeen, "Lady Dorothy" (8688).
4th. R. Sinclair Scott, Burnside, Largs, Ayrshire, "Irene."

CLASS 45. FILLY, foaled in 1891.—Premiums, £10, £6, £3, and £2.

1st. William Graham, Edengrove, Penrith, "Royal Rose."
2d. William W. Galbraith, Croftfoot, Gartcosh, "Nada."
3d. William Park, Brunstane, Portobello, "Lady Louisa."
4th. James A. Whyte, Kirkmabreck, Sandhead, Wigtownshire, "Ethel of Kirkmabreck."

CLASS 46. FILLY, foaled in 1892.—Premiums, £10, £6, £3, and £2.

1st. James F. Murdoch, East Hallside Farm, Newton, "Lady Lockhart."
2d. William Graham, Edengrove, Penrith, "Lady Patricia."
3d. Alexander M'G. Mennie, Brawlandknowes, Gartly, "Princess of Haulkerton."
4th. John Gilmour, Montrave, Leven, Fife, "Montrave Gladys."

CLASS 47. FILLY, foaled in 1893.—Premiums, £10, £6, £3, and £2.

1st. J. Douglas Fletcher, of Rosehaugh, Avoch, N.B., "Duchess of York."
2d. Colonel Stirling, of Kippendavie, Kippenross Home Farm, Dunblane, "Princess May."
3d. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.
4th. John Gilmour, Montrave, Leven, Fife, "Montrave Rebecca."

## DRAUGHT GELDINGS.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Draught Gelding in Classes* 48 *to* 50.

William Clark, Netherlee, Cathcart, "Sensation."

CLASS 48. DRAUGHT GELDING, foaled before 1st January 1891.—
Premiums, £8, £4, and £2.

1st. William Clark, Netherlee, Cathcart, "Sensation."
2d. James Young & Sons, Railway Contractors, Edinburgh, "Nobleman."
3d. James Durno, Jackstown, Rothienorman, "Prince."
H.C. John Brown, Craigie Cottage, Hardgate, Aberdeen, "Spring."

CLASS 49. DRAUGHT GELDING, foaled in 1891.—Premiums, £8, £4, and £2.

1st. William Clark, Netherlee, Cathcart, "Amazement."
2d. James Young & Sons, Railway Contractors, Edinburgh, "Jim."
3d. James Bean, Mains of Dumbreck, Udny, "Star."
H.C. William Charles, Gammons, Rothienorman, "Prince."

CLASS 50. DRAUGHT GELDING, foaled in 1892.—Premiums, £5, £3, and £2.

1st. William Clark, Netherlee, Cathcart, "Chance."
2d. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis, "Liberator."
3d. George A. Ferguson, Lessendrum, Huntly, "Spey."
C. James Davidson, Newton of Cairnie, Huntly, "Prince."

## ROAD OR FIELD.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Hunter in Class* 51.

John Gilmour, of Montrave, Leven, Fife, Gelding, "Nimrod."

CLASS 51. HUNTER, Mare or Gelding, foaled before 1st January 1891, *in saddle.*—Premiums, £10, £5, and £3.

1st. John Gilmour, Montrave, Leven, Fife, Gelding, "Nimrod."
2d. Lord Saltoun, Philorth, Fraserburgh, Mare, "Norah."
3d. Alexander MacGregor, M.D., 256 Union Street, Aberdeen, Gelding, "Tommy."

*H.R.H. THE DUKE OF YORK'S MEDAL for best Roadster in Classes* 52 *to* 55.

Charles E. Galbraith, Ayton Castle, Ayton, N.B., Mare, "Lady Ulrica" (4204).

CLASS 52. MARE or GELDING, foaled before 1st January 1891, 15 hands and upwards, *in saddle.*—Premiums, £8, £4, and £2.

1st. G. J. Buchanan-Fergusson, of Auchentorlie, Bowling, Mare, "Judy."
2d. George Arbuthnot-Leslie, Warthill, Aberdeen, Gelding, "Rufus."
3d. James Brown, Elrick, Alford, N.B., Gelding, "Stanley."

CLASS 53. MARE or GELDING, foaled before 1st January 1891, 14.2 and under 15 hands, *in saddle.*—Premiums, £8, £4, and £2.

1st. Charles E. Galbraith, Ayton Castle, Ayton, N.B., Mare, "Lady Ulrica" (4204).
2d. J. & A. Munro, the City Stables, Elgin, Mare, "Lady Munro."
3d. Miss Crane, Elmfield, Aberdeen, Gelding, "Garry."
V.H.C. Captain Pierrepont Brooke, 79th Highlanders, Banchory, N.B., Mare, "Dinah Shadd."

CLASS 54. MARE or GELDING, foaled in 1891, *in hand.*—Premiums, £6, £4, and £2.

1st. H. V. Haig, Ramornie, Ladybank, Fife, Gelding.
2d. William Stewart Menzies, Chesthill, Aberfeldy, Mare.
3d. James Brown, Elrick, Alford, N.B., Mare, "Flora."
V.H.C. Sir William Henderson, Devanha House, Aberdeen, Mare, "Yildiz."
H.C. George Inglis, Newmore, Invergordon, Gelding, "Sugar Candy."
C. Alexander Stott, Causeyport, Portlethen, Aberdeen, Mare, "Fleetwing."

CLASS 55. MARE or GELDING, foaled in 1892, *in hand.*—Premiums, £6, £4, and £2.

1st. H. V. Haig, Ramornie, Ladybank, Mare.
2d. John Gilmour, Montrave, Leven, Fife, Mare, "Crocus."
3d. John Brown, Craigie Cottage, Hardgate, Aberdeen, Gelding, "Prince Robert."
V.H.C. Charles Birse, Mayfield, Whitehouse, Filly, "Lady Cyprus."
H.C. John Brown, Craigie Cottage, Hardgate, Aberdeen, Filly.
C. William Stewart Menzies, Chesthill, Aberfeldy, Mare.

CLASS 56. COLT or FILLY, foaled in 1893, the produce of Thoroughbred Stallions, out of Mares of any breed.—Five Prizes—£10, £7, £5, £2, and £1, given by Mr Gilmour of Montrave.

1st. George Inglis, Newmore, Invergordon, Colt, "Lionel."
2d. H. V. Haig, Ramornie, Ladybank, Gelding.
3d. Captain Clayhills Henderson of Invergowrie, R.N., Dundee, Filly, "Princess Charlotte."
4th. D. C. Bruce, Byres Farm, Fochabers, Filly, "Queen Charlotte."
5th. David Mitchell, Millfield, Polmont, Filly, "Julia."
C. George Bruce, Tochineal, Cullen, Filly.

## HACKNEYS.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Hackney in Classes* 57 *to* 64.

Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Danebury" (4724).

*Best Mare or Filly in Hackney Pony Classes*—Prize of £10 and Bronze Medal, given by the Hackney Horse Society. A Mare 6 years old or more must have had a foal. Winners of the Hackney Society's Medals in 1894, except at the London and Royal English Shows, excluded. The winner must be entered or accepted for entry in Hackney Stud-Book, and certified free from hereditary disease.

Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Linda" (4234).

CLASS 57. STALLION, any Age, over 14.2 hands, registered in the Hackney Stud-Book.—Premiums, £10, £5, and £2.

1st. Her Majesty the Queen, Birkhall, Ballater, "Vidette 2d" (4568).
2d. P. & W. Crawford, Eastfield House, Dumfries, "Dash It All" (4220).
3d. Dr George Hugh Mackay, 13 North Street, Elgin, "Bay Fireaway 3d" (3439).
C. J. Harriott Bell, Rossie, Forgandenny, "Vandyke" (4560).

CLASS 58. BROOD MARE, 15 hands and upwards, with Foal at foot, or to foal this season to a registered sire. Registered in the Hackney Stud-Book.—Premiums, £7, £4, and £2.

1st. Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Lund Lassie" (4262).

CLASS 59. BROOD MARE, under 15 hands, with Foal at foot, or to foal this season to a registered sire. Registered in the Hackney Stud-Book.—Premiums, £7, £4, and £2.

1st. Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Linda" (4234).
2d. Gordon Reid Shiach, Elgin, "Adelina" (1413).
3d. Alexander Leslie of Braco, Keith, "Laurette" (2213).
H.C. Alexander Leslie of Braco, Keith, "Lottie Collins" (5712).

CLASS 60. FILLY, foaled in 1891, got by registered hackney sire.—Premiums, £5, £3, and £1.

1st. James Walker, Limefield, West Calder, "Dearest" (5211).
2d. David Mitchell, Millfield, Polmont, "Daybreak."

CLASS 61. FILLY, foaled in 1892, got by registered hackney sire.—Premiums, £5, £3, and £1.

1st. Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Veronica" (7529).
2d. John M. Martin, Auchendennan, Balloch, "Lady Glencoe."
3d. Alexander Hay, Pinewood Park, Rubislaw, Aberdeen, "Paulin."
H.C. Robert Moir, Tarty, Ellon, "Dodo."

CLASS 62. FILLY, foaled in 1893, got by registered hackney sire.—Premiums, £5, £3, and £1.

1st. Gavin Hadden, Dalmuinzie, Murtle, Aberdeen, "Danish Poppy."
2d. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, "Fairfield."
3d. J. Harriott Bell, Rossie, Forgandenny, "Daisy Bell."
C. Alexander Leslie, of Braco, Keith, "Dewdrop."

CLASS 63. ENTIRE COLT, foaled in 1892, registered in Hackney Stud-Book. —Premiums, £5, £3, and £1.

1st. Charles E. Galbraith, Ayton Castle, Ayton, N.B., "Danebury" (4724).
2d. Gavin Hadden, Dalmuinzie, Murtle, Aberdeen, "Matchless Confidence" (4898).

CLASS 64. ENTIRE COLT, foaled in 1893, eligible for entry in Hackney Stud-Book.—Premiums, £5, £3, and £1.

1st. Alexander Leslie, of Braco, Keith, "Brown Douglas."
2d. Sir Robert D. Moncreiffe, Bart., Moncreiffe House, Bridge of Earn, "Moncreiffe Matchless."

## DRIVING COMPETITIONS.

CLASS 65. Best TURN-OUT of SINGLE HORSE, HARNESS, and TRAP, to be driven in the ring, 15 hands and upwards.—Premiums, £8, £4, and £2.

1st. G. J. Buchanan-Fergusson of Auchentorlie, Bowling, Mare, "Judy."
2d. George Arbuthnot-Leslie, Warthill, Aberdeen, Gelding, "Rufus."
3d. Lord Saltoun, Philorth, Fraserburgh, Mare, "Bay Leaf."
H.C. James B. Whitelaw, St Fort, Newport, Fife, Gelding, "Hornbeam" (2517).
C. James Brown, Elrick, Alford, N.B., Gelding, "Delgaty."

CLASS 66. Best TURN-OUT of SINGLE HORSE, HARNESS, and TRAP, to be driven in the ring, under 15 hands.—Premiums, £8, £4, and £2.

1st. Sir Allan Mackenzie, Bart., of Glenmuick, Ballater, Mare, "Dodo."
2d. J. & J. Munro, the City Stables, Elgin, Mare, "Lady Helen."
3d. Miss Crane, Elmfield, Aberdeen, Gelding, "Garry."
H.C. David Mitchell, Millfield, Polmont, "Daybreak."
C. Edmund Barrie, 32 Elmfield Avenue, Aberdeen, Gelding, "Rufus."
C. James Henderson, Orchard Cottage, Old Aberdeen, "Triptolemus" (45).

## PONIES.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Pony in Classes 67 to 71.*

John M'Callum, 95 Dundas Street, City, Glasgow, "Sir John" (3280).

CLASS 67. STALLION, over 12, not exceeding 14.2 hands.—Premiums, £4, £2, and £1.

1st. John M'Callum, 95 Dundas Street, City, Glasgow, "Sir John" (3280).
2d. Gordon Reid Shiach, Elgin, "Lucifer."
3d. Martin L. Hadden, Binghill, Murtle, "Sir Christopher" (4501).
H.C. J. Harriott Bell, Rossie, Forgandenny, "Erl King 2d" (3573).

CLASS 68. MARE or GELDING, between 13 and 14½ hands.—Premiums, £4, £2, and £1.

1st. Sir Allan Mackenzie, Bart., of Glenmuick, Ballater, Mare, "Dodo."
2d. David Mitchell, Millfield, Polmont, Mare, "Brown Berry" (1463).
3d. Alexander Leslie, of Braco, Keith, Mare, "Lady Braco" (6851).
H.C. J. & A. Munro, the City Stables, Elgin, Mare, "Lady Helen."
C. Robert Clarke, Waterside, Banchory-Devenick, Aberdeen, Mare.

CLASS 69. MARE or GELDING, between 12 and 13 hands.—Premiums, £4, £2, and £1.

1st. David Davidson, 21 Queen's Road, Aberdeen, Mare, "Daisy."
2d. Martin L. Hadden, Binghill, Murtle, Gelding, "Goldfinch."
3d. J. Harriott Bell, Rossie, Forgandenny, Gelding, "Victor."
H.C. Francis C. Mackenzie, 72 Loch Street, Aberdeen, Mare, "Bessie."
C. Robert Forbes, Woodhead, Kinloss, Forres, Gelding, "Donald."

CLASS 70. STALLION, under 12 hands.—Premiums, £4, £2, and £1.

1st. Donald M. MacRae, Stenhouse, Thornhill, "Tommy 2d" (2737).

CLASS 71. MARE or GELDING, under 12 hands.—Premiums, £4, £2, and £1.

1st. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, Mare, "Pride."
2d. J. Harriott Bell, Rossie, Forgandenny, Mare, "Mousie."
3d. Martin L. Hadden, Binghill, Murtle, Mare, "Jenny Wren."
H.C. James M'Intosh, Middleton, Nigg, Aberdeen, Gelding, "Dobbin."
C. Wm. Pyper of Hillhead, Aberdeen, Mare, "Bessy."

## SHETLAND PONIES.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Shetland Pony in Classes 72 to 74.*

C. Macpherson-Grant, Drumduan, Forres, "Harold."

CLASS 72. STALLION, above 3 years, not exceeding 10½ hands.—Premiums, £4, £2, and £1.

1st. C. Macpherson-Grant, Drumduan, Forres, "Harold."
2d. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, "Siguard."
3d. The Countess of Hopetoun, Hopetoun House, South Queensferry, "Monster."
V.H.C. Anderson Manson, Laxfirth, Lerwick, "Snowdrop."
H.C. Anderson Manson, Laxfirth, Lerwick, "Tom Thumb" (82).
C. William Lawrence Bell, 5 Portland Street, Southampton, "Trump."

CLASS 73. MARE or GELDING, above 3 years, not exceeding 10½ hands.—Premiums, £4, £2, and £1.

1st. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, Mare, "Sigfus" (675).
2d. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, Mare, "Hildigunna" (668).
3d. Anderson Manson, Laxfirth, Lerwick, Mare, "Nellie" (726).
V.H.C. C. Macpherson-Grant, Drumduan, Forres, Mare, "Susan."
H.C. C. Macpherson-Grant, Drumduan, Forres, Mare, "Merry Midget."
C. James Henderson, Orchard Cottage, Old Aberdeen, Mare, "Jenny Lind" (651).

CLASS 74. MARE or GELDING, under 3 years, not exceeding 10½ hands.—Premiums, £4, £2, and £1.

1st. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, Gelding.
2d. C. Macpherson-Grant, Drumduan, Forres, Mare, "Rebecca."
3d. The Marquis of Londonderry, K.G., Seaham Hall, Seaham Harbour, Filly.

## EXTRA HORSES.

The following were Very Highly Commended and Medium Gold Medals awarded:—

J. Harriott Bell, Rossie, Forgandenny, Roadster Gelding, "The Masher."
John Gilmour, Montrave, Leven, Clydesdale Mare, "Moss Rose" (6203).
Gavin Hadden, Dalmuinzie, Murtle, Aberdeen, Hackney Stallion, "Challenger" 3103).

The following was Highly Commended and a Minor Gold Medal awarded:—

George A. Ferguson, Lessendrum, Huntly, Gelding, "Mighty Dollar."

## JUMPING COMPETITIONS.

*Champion Prize of* £10, given by Sir Allan Mackenzie, Bart., and Mr Gordon of Newton, *for the Winner of most Points in Prizes in the Jumping Competitions.*

*Conditions*—First Prize to count three points, Second Prize two points, and Third Prize one point—the money to be divided in the event of equality.

*Wednesday, 25th July.*

CLASS 1. HORSES, Open.—Premiums, £20, £10, and £5.

1st. David Sprott, Crown Inn, Alva, Gelding, "Weaver."
2d. William Taylor, Park Mains, Renfrew, Gelding, "Clown."
3d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Gelding, "Silver King."

CLASS 2. PONIES, 14½ Hands and under.—Premiums, £5, £3, and £1.

1st. D. Carnegie, East Pitcorthie, Colinsburgh, Gelding, "Baylark."
2d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Mare, "Silver Queen."

*Wednesday Evening at* 6.30.

(Prizes contributed by Show Purveyors and others.)

CLASS 7. HORSES, Open.—Premiums, £6, £2, and £1.

1st. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Gelding, "Silver King."
2d. Aberdeen Riding Academy, 25 Albyn Lane, Aberdeen, Gelding, "Billy."
3d. M. Greenlees, jun., 167 George Street, Paisley, Mare, "Priestess."

CLASS 8. PONIES, 14½ Hands and under.—Premiums, £3 and £1.

1st. D. Carnegie, East Pitcorthie, Colinsburgh, Gelding, "Baylark."
2d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Mare, "Silver Queen."

*Thursday, 26th July.*

CLASS 3. HORSES, Open Handicap, hurdles and gate being raised 8 inches for the winner of the first prize, and 4 inches for the winner of the second prize in Class 1.—Premiums, £10, £6, and £3.

1st. Mrs Crane, Elmfield, Aberdeen, Gelding, "Punchestown."
2d. R. Swinhoe, 5 Cross Street, Newcastle-on-Tyne, Gelding, "Sky Pilot."
3d. M. Greenlees, jun., 167 George Street, Paisley, Mare, "Priestess."

CLASS 4. PONIES, 14½ Hands or under, Handicap, hurdles and gate being raised 4 inches for the first prize winner in Class 2.—Premiums, £5, £3, and £1.

1st. D. Carnegie, East Pitcorthie, Colinsburgh, Gelding, "Baylark."
2d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Pony, Mare, "Silver Queen."

*Thursday Evening at* 6.30.

(Prizes contributed by Show Purveyors and others.)

CLASS 9. HORSES, Open Handicap, hurdles and gate being raised 8 inches for the winner of a first prize and 4 inches for the winner of a second prize for jumping on Wednesday afternoon or evening.—Premiums, £5, £2, and £1.

1st. M. Greenlees, jun., 167 George Street, Paisley, Mare, "Priestess."
2d. Mrs Crane, Elmfield, Aberdeen, Gelding, "Punchestown."
3d. Aberdeen Riding Academy, 25 Albyn Lane, Aberdeen, Gelding, "Billy."

CLASS 10. PONIES, 14½ hands or under, Handicap, hurdles and gate being raised 4 inches for a first prize winner for jumping on Wednesday afternoon or evening. Premiums, £2 and £1.

1st. D. Carnegie, East Pitcorthie, Colinsburgh, Gelding, "Baylark."
2d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Mare, "Silver Queen."

*Friday, 27th July.*

CLASS 5. HORSES, Open Handicap, hurdles and gates being raised 8 inches for the winner of the first prize, and 4 inches for the winner of the second prize in either of Classes 1 or 3—4 inches extra for the winner of the two first prizes in Classes 1 and 3.—Premiums, £10, £6, and £3.

1st. Marius Bell, Broats, Annan, "Mare, Border Witch."
2d. William Connelly, Bellrigg, Castle-Douglas, Mare, "Little Wonder."
3d. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Gelding, "Silver King."
H.C. Aberdeen Riding Academy, 25 Albyn Lane, Aberdeen, Gelding, "Billy."

CLASS 6. PONIES, 14½ hands or under, Handicap, hurdles and gate being raised 4 inches for the winner of the first prize in Class 2 or in Class 4, and 8 inches for winner of the first prize in both these Classes.—Premiums, £3, £2, and £1.

1st. David Courage, Royal Oak Bar, Marischal Street, Aberdeen, Pony, Mare, "Silver Queen."
2d. Aberdeen Riding Academy, 25 Albyn Lane, Aberdeen, Mare, "Milly."
3d. D. Carnegie, East Pitcorthie, Colinsburgh, Gelding, "Baylark."

CHAMPION PRIZE OF £10, given by Sir ALLAN MACKENZIE, Bart., and Mr GORDON of Newton, for the Winner of most points in Prizes in the above Jumping Competitions—First Prize to count three points, Second Prize two points, and Third Prize one point—the money to be divided in the event of equality.

David Courage, Royal Oak Bar, Marischal Street, Aberdeen, nine points.

## SHEEP

### BLACKFACED.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Pen of Blackfaced Sheep in Classes* 75 *to* 81.

C. Howatson of Dornel, Glenbuck, N.B.

*Best Ram in Classes* 75 *to* 78—Champion Prize of £10, given by Mr Howatson of Dornel.

C. Howatson of Dornel, Glenbuck, N.B.

CLASS 75. TUP, three Shear or upwards.—Premiums, £10, £5, and £3.

1st. C. Howatson of Dornel, Glenbuck, N.B.
2d. C. Howatson of Dornel, Glenbuck, N.B.

CLASS 76. TUP, two Shear.—Premiums, £10, £5, and £3.

1st. C. Howatson of Dornel, Glenbuck, N.B.
2d. The Duke of Argyll, K.G., Ballymenach, Campbeltown.
3d. John Craig, Innergeldie, Comrie.
V.H.C. C. Howatson of Dornel, Glenbuck, N.B.
H.C. C. Howatson of Dornel, Glenbuck, N.B.
C. John Craig, Innergeldie, Comrie.

CLASS 77. SHEARLING TUP.—Premiums, £10, £5, and £3.

1st. C. Howatson of Dornel, Glenbuck, N.B.
2d. C. Howatson of Dornel, Glenbuck, N.B.
3d. R. & J. Cadzow, Borland, Biggar.
V.H.C. C. Howatson of Dornel, Glenbuck, N.B.
H.C. C. Howatson of Dornel, Glenbuck, N.B.
C. R. & J. Cadzow, Borland, Biggar.
C. C. Howatson of Dornel, Glenbuck, N.B.

CLASS 78. Five SHEARLING TUPS, bred and fed by Exhibitor. The Tups to be offered for *bonâ fide* sale, and sold without reserve, at any of the following Ram Sales in 1894—viz., Ayr, Edinburgh (Lothian Ram Sales), Glasgow, Lanark, Oban, or Perth—The Ayrshire Plate of 40 Sovereigns. Given by Mr Howatson of Dornel.

Charles Howatson of Dornel, Glenbuck.

CLASS 79. Three EWES, above one Shear, with their Lambs at foot.—Premiums, £8, £4, and £2.

1st. D. T. Martin, Girgenti, Irvine.
2d. The Duke of Argyll, K.G., Ballymenach, Campbeltown.
3d. John Craig, Innergeldie, Comrie.
V.H.C. P. M. Turnbull, Smithston, Gartly.
H.C. P. M. Turnbull, Smithston, Gartly.
C. David Reid, Crofts of Glenmuick, Ballater.

*Best Pen of Blackfaced Ewes or Gimmers in Classes* 79 *and* 80—Champion Prize Cup, value £10, given by Sir T. D. Gibson Carmichael, Bart.

D. T. Martin, Girgenti, Irvine.

CLASS 80. Three SHEARLING EWES or GIMMERS.—Premiums, £8, £4, and £2.

1st. The Duke of Argyll, K.G., Ballymenach, Campbeltown.
2d. D. T. Martin, Girgenti, Irvine.
3d. The Duke of Argyll, K.G., Ballymenach, Campbeltown.
V.H.C. Earl of Ancaster, Glenartney Forest, Comrie.
H.C. P. M. Turnbull, Smithston, Gartly.
C. Wm. Wilson, Coynachie, Gartly, N.B.

CLASS 81. TUP LAMB.—Premium, £3, given by Mr Howatson of Dornel.

D. T. Martin, Girgenti, Irvine.

*Sheep (entered in any of the above classes, male or female) carrying the fleece best adapted for protecting the animal in a highly exposed and stormy climate*—£2, given by Mr Howatson of Dornel.

The Duke of Argyll, K.G., Ballymenach, Campbeltown.

*For the Shepherds in charge of the Blackfaced Sheep gaining the largest amount of money in Prizes*—First Prize, £3; Second Prize, £2, given by Mr Howatson of Dornel.

1st. Shepherd in charge of Sheep belonging to Mr Howatson of Dornel.
2d. Shepherd in charge of Sheep belonging to the Duke of Argyll, K.G.

## CHEVIOT.

*H.R.H. THE DUKE OF YORK'S MEDAL for best pen of Cheviot Sheep in Classes* 82 *to* 85.

John Elliot, Hindhope, Jedburgh.

CLASS 82. TUP, above one Shear.—Premiums, £10, £5, and £3.

1st. John Elliot, Hindhope, Jedburgh.
2d. John Robson, Newton, Bellingham.
3d. John Elliot, Hindhope, Jedburgh.
V.H.C. John A. Johnstone, Archbank, Moffat.
H.C. John A. Johnstone, Archbank, Moffat.
C. John A. Johnstone, Archbank, Moffat.

CLASS 83. SHEARLING TUP.—Premiums, £10, £5, and £3.

1st. John Elliot, Hindhope, Jedburgh.
2d. James Moffat, Craick, Hawick.
3d. John Robson, Newton, Bellingham.
V.H.C. John A. Johnstone, Archbank, Moffat.
H.C. John Elliot, Hindhope, Jedburgh.
C. John A. Johnstone, Archbank, Moffat.

CLASS 84. Three EWES, above one Shear, with their Lambs at foot.—Premiums, £8, £4, and £2.

1st. John Robson, Newton, Bellingham.
2d. Jacob Robson, Byrness, Otterburn, Northumberland.
3d. Jacob Robson, Byrness, Otterburn, Northumberland.

CLASS 85. Three SHEARLING EWES or GIMMERS.—Premiums, £8, £4, and £2.

1st. John Robson, Newton, Bellingham.
2d. Jacob Robson, Byrness, Otterburn, Northumberland.
3d. John A. Johnston, Archbank, Moffat.

## BORDER LEICESTER.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Pen of Border Leicesters in Classes 86 to 89.*

Thomas Clark, Oldhamstocks Mains, Cockburnspath.

*THE TWEEDDALE GOLD MEDAL, Value £20, given for the best Border Leicester Tup.*

Thomas Clark, Oldhamstocks Mains, Cockburnspath.

CLASS 86. TUP, above one Shear.—Premiums, £10, £5, and £3.

1st. Thomas Clark, Oldhamstocks Mains, Cockburnspath.
2d. William Ford, Fentonbarns, Drem.
3d. The Duke of Buccleuch and Queensberry, K.T., Dalkeith Park, Dalkeith.
V.H.C. Quentin Dunlop, Morriston, Maybole.
H.C. William L. Cochrane, Milton of Leask, Ellon.
C. James Nisbet, Lambden, Greenlaw.
C. The Earl of Rosebery, Dalmeny Park, Linlithgowshire.

CLASS 87. SHEARLING TUP.—Premiums, £10, £5, and £3.

1st. Thomas Clark, Oldhamstocks Mains, Cockburnspath.
2d. The Earl of Rosebery, Dalmeny Park, Linlithgowshire.
3d. The Duke of Buccleuch and Queensberry, K.T., Dalkeith Park, Dalkeith.
V.H.C. Thomas Clark, Oldhamstocks Mains, Cockburnspath.
H.C. Thomas Clark, Oldhamstocks Mains, Cockburnspath.
C. William Ford, Fentonbarns, Drem.

CLASS 88. Three EWES, above one Shear.—Premiums, £8, £4, and £2.

1st. George Robeson, Springwells, Coldstream.

CLASS 89. Three SHEARLING EWES or GIMMERS.—Premiums, £8, £4, and £2.

1st. Thomas Clark, Oldhamstocks Mains, Cockburnspath.
2d. William Ford, Fentonbarns, Drem.
3d. W. S. Ferguson, Pictstonhill, Perth.
H.C. Right Hon. Arthur James Balfour, M.P., Whittinghame, Prestonkirk.
C. The Earl of Dalhousie, Panmure, Carnoustie.

## SHROPSHIRE.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Pen of Shropshires in Classes 90 to 93.*

David Buttar, Corston, Coupar-Angus.

CLASS 90. TUP, above one Shear.—Premiums, £6, £4, and £2.

1st. David Buttar, Corston, Coupar-Angus.
2d. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.
3d. David Buttar, Corston, Coupar-Angus.
H.C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.

CLASS 91. SHEARLING TUP.—Premiums, £6, £4, and £2.

1st. David Buttar, Corston, Coupar-Angus.
2d. David Buttar, Corston, Coupar-Angus.
3d. David Buttar, Corston, Coupar-Angus.
V.H.C. David Buttar, Corston, Coupar-Angus.
H.C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.

CLASS 92. Three EWES, above one Shear.—Premiums, £5, £3, and £2.

1st. David Buttar, Corston, Coupar-Angus.
2d. David Buttar, Corston, Coupar-Angus.

CLASS 93. Three SHEARLING EWES or GIMMERS.—Premiums, £5, £3, and £2.

1st. David Buttar, Corston, Coupar-Angus.
2d. David Buttar, Corston, Coupar-Angus.
3d. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.
C. The Earl of Strathmore, Home Farm, Glamis Castle, Glamis.

## EXTRA SECTIONS.

*H.R.H. THE DUKE OF YORK'S MEDAL for best Pen of Fat Sheep in Classes 94 to 99.*

John Gilmour of Lundin and Montrave, Leven, Fife.

*Best Pen of Blackfaced Wethers in Classes 94 or 95, age and quality considered*—£2, given by Mr Howatson of Dornel.

P. M. Turnbull, Smithston, Gartly.

CLASS 94. Three BLACKFACED WETHERS, two Shear.—Premiums, £4 and £2.

1st. W. S. Ferguson, Pictstonhill, Perth. Weight, 5 cwt. 0 qr. 16 lb.
2d. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 5 cwt. 0 qr. 19 lb.

CLASS 95. Three BLACKFACED WETHERS, one Shear.—Premiums, £4 and £2.

1st. P. M. Turnbull, Smithston, Gartly. Weight, 4 cwt. 2 qr. 6 lb.
2d. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 4 cwt. 1 qr. 17 lb.
H.C. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 4 cwt. 0 qr. 27 lb.

CLASS 96. Three CHEVIOT WETHERS, two Shear.—Premiums, £4 and £2.

1st. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 6 cwt. 0 qr. 27 lb.

CLASS 97. Three CHEVIOT WETHERS, one Shear.—Premiums, £4 and £2.

1st. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 4 cwt. 3 qr. 9 lb.
2d. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 4 cwt. 3 qr. 2 lb.

CLASS 98. Three CROSS-BRED WETHERS, one Shear.—Premiums, £4 and £2.

1st. Wm. Charles, Gammons, Rothienorman. Weight, 5 cwt. 0 qr. 12 lb.
2d. John Gilmour of Lundin and Montrave, Leven, Fife. Weight, 5 cwt. 2 qr. 7 lb.

*Best Pens of Cross-bred Lambs in Class 99 got by a Shropshire Tup*—First Prize, £5; Second, £3; Third, £2—given by Scotch Breeders of Shropshire Sheep, per Mr Buttar.

1st. Alex. Anderson, Berryhill, Dundee, Shropshire Dorset Horn.
2d. James Brander, Pittendreich, Elgin, Shropshire Cotswold.
3d. George F. Barron, Meikle Endovie, Alford, Cross.

CLASS 99. Five FAT LAMBS, any Breed or Cross.—Premiums, £4 and £2.

1st. Alex. Anderson, Berryhill, Dundee, Shropshire Dorset Horn. Weight, 6 cwt. 1 qr. 3 lb.
2d. James Brander, Pittendreich, Elgin, Shropshire Cotswold. Weight, 6 cwt. 2 qr. 16 lb.
H.C. George F. Barron, Meikle Endovie, Alford, Cross. Weight, 5 cwt. 1 qr. 13 lb.

EXTRA SHEEP.

The following was Very Highly Commended and Minor Gold Medal awarded:—

P. M. Turnbull, Smithston, Gartly, Blackfaced Ewe.

## SWINE

*Owing to an outbreak of Swine Fever in the district, no Swine exhibited.*

## POULTRY

First Premium—*One Sovereign.* Second Premium—*Ten Shillings.* One *Commended* Ticket—in all the Sections.

CLASS 1. DORKING, Silver Grey. Cock.

1st. John Cran, Old Keith, Keith.
2d. Charles Aitkenhead, The Dene, Seaham Harbour.
C. Samuel Angus, Bonnymuir, Aberdeen.

CLASS 2. DORKING, Silver Grey. Hen.

1st. James Clunas, 76 High Street, Elgin.
2d. James Annand, Ironmonger, Keith.
C. Alex. Moir, Gladstone Bank, Woodside, Aberdeen.

CLASS 3. DORKING, Silver Grey. Cockerel.

1st. Robert Wood, Panmure, Carnoustie.
2d. James Clunas, 76 High Street, Elgin.
C. James Clunas, 76 High Street, Elgin.

CLASS 4. DORKING, Silver Grey. Pullet.

1st. James Clunas, 76 High Street, Elgin.
2d. Robert Wood, Panmure, Carnoustie.
C. James Clunas, 76 High Street, Elgin.

CLASS 5. DORKING, Coloured. Cock.

1st. Andrew Crichton, Glamis, Forfarshire.
2d. John Cran, Old Keith, Keith.
C. John Gillies, Edington Mills, Chirnside.

CLASS 6. DORKING, Coloured. Hen.

1st. John Cran, Old Keith, Keith.
2d. The Countess of Aberdeen, Haddo House, Aberdeen.
C. John Gillies, Edington Mills, Chirnside.

CLASS 7. DORKING, Coloured. Cockerel.

1st. Andrew Crichton, Glamis, Forfarshire.
2d. John Gillies, Edington Mills, Chirnside.
C. Peter Garrow, Dunkinty, Elgin.

CLASS 8. DORKING, Coloured. Pullet.

1st. Mrs D. Mackenzie, Meigle.
2d. Andrew Crichton, Glamis, Forfarshire.
C. John Gillies, Edington Mills, Chirnside.

CLASS 9. COCHIN-CHINA. Cock.

1st. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.
2d. David Miller, 15 Reform Street, Dunfermline.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

CLASS 10. COCHIN-CHINA. Hen.

1st. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.

CLASS 11. COCHIN-CHINA. Cockerel.

1st. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.
2d. Rev. George Ramsden, The Parsonage, Glamis.
C. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.

CLASS 12. COCHIN-CHINA. Pullet.

1st. Rev. George Ramsden, The Parsonage, Glamis.
2d. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.
C. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.

CLASS 13. BRAHMAPOOTRA. Cock.

1st. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.
2d. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.
C. Alexander Brand, Saw-Mill House, Bonnybridge.

CLASS 14. BRAHMAPOOTRA. Hen.

1st. John Gillies, Edington Mills, Chirnside.
2d. John Bruce, Lodge, Binrock, Dundee.
C. Mrs Leslie, 28 Elmfield Avenue, Aberdeen.

CLASS 15. BRAHMAPOOTRA. Cockerel.

1st. Rev. George Ramsden, The Parsonage, Glamis.
2d. William Bruce, Lodge, Binrock, Dundee.
C. James Lorimer, Sandridge Cottage, Monifieth.

CLASS 16. BRAHMAPOOTRA. Pullet.

1st. William Bruce, Lodge, Binrock, Dundee.
2d. James Lorimer, Sandridge Cottage, Monifieth.
C. Rev. George Ramsden, The Parsonage, Glamis.

CLASS 17. SCOTCH GREY. Cock.

1st. W. S. Mitchell, Castle Orchards, Airth, Larbert.
2d. W. S. Mitchell, Castle Orchards, Airth, Larbert.

CLASS 18. SCOTCH GREY. Hen.

1st. W. S. Mitchell, Castle Orchards, Airth, Larbert.
2d. James Greenshields, West Town, Lesmahagow.
C. W. S. Mitchell, Castle Orchards, Airth, Larbert.

CLASS 19. SCOTCH GREY. Cockerel.

1st. A. W. Henderson, Airthrey Mills, Bridge of Allan.
2d. A. W. Henderson, Airthrey Mills, Bridge of Allan.
C. Archibald Mitchell, Castle Orchards, Airth, Larbert.

CLASS 20. SCOTCH GREY. Pullet.

1st. Archibald Mitchell, Castle Orchards, Airth, Larbert.
2d. James Greenshields, West Town, Lesmahagow.
C. John M. Martin, Auchendennan, Balloch.

CLASS 21. HAMBURG. Cock.

1st. J. M. Campbell, Bonny Kelly, New Deer.
2d. James Huntly, Edington Mills, Chirnside.
C. H. B. Gibb, Dorrator House, Falkirk.

CLASS 22. HAMBURG. Hen.

1st. J. R. Mearns, 11 Princes Street, Aberdeen.
2d. Mrs Andrew Shepherd, Paradise Cottages, Kemnay.
C. Mrs Andrew Shepherd, Paradise Cottages, Kemnay.

CLASS 23. HAMBURG. Cockerel.

1st. J. M. Campbell, Bonny Kelly, New Deer.
2d. Alexander Fraser, Newmills, Alves, Forres.
C. William Watson, Arns Farm, Clackmannan.

CLASS 24. HAMBURG. Pullet.

1st. Maurice Jackson, High Green Farm, Silsden, near Keighley, Yorkshire.
2d. J. M. Campbell, Bonny Kelly, New Deer.
C. Alexander Fraser, Newmills, Alves, Forres.

CLASS 25. PLYMOUTH ROCK. Cock.

1st. Amy Clark, Udny Castle, Aberdeen.
2d. Rev. Fitzroy Lloyd, The Priory, Pittenweem.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

CLASS 26. PLYMOUTH ROCK. Hen.

1st. Rev. Fitzroy Lloyd, The Priory, Pittenweem.
2d. The Countess of Aberdeen, Haddo House, Aberdeen.

CLASS 27. PLYMOUTH ROCK. Cockerel.

1st. John M. Martin, Auchendennan, Balloch.
2d. Rev. Fitzroy Lloyd, The Priory, Pittenweem.
C. A. F. Davidson, 91 Regent Street, Fife-Keith, Keith.

CLASS 28. PLYMOUTH ROCK. Pullet.

1st. L. H. & J. Nutter, Croft House, Burton, Westmoreland.
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

CLASS 29. MINORCA. Cock.

1st. William D. Brownie, Ellon, Aberdeen.
2d. Alexander Cran, Stonecutter, Ellon.

CLASS 30. MINORCA. Hen.

1st. George Bryce, Grove End, Lasswade.
2d. John Spring, Auchinleck, Skene.
C. James W. Cormack, Kinmundy, New Machar, by Summerhill, Aberdeen.

CLASS 31. MINORCA. Cockerel.

1st. John Lawson, Rose Cottage, Culross.
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
C. Alexander Cran, Stonecutter, Ellon.

CLASS 32. MINORCA. Pullet.

1st. John W. Crossman, Galphay, Ripon.
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
C. Mrs D. Mackenzie, Meigle.

### Class 33. LEGHORN. Cock.

1st. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
2d. Mrs Devlin, Cemetery Road, Dunfermline.
C. Wm. Wedderburn, Hatton, Fintray, Aberdeen.

### Class 34. LEGHORN. Hen.

1st. John Devlin, Cemetery Road, Dunfermline.
2d. Frank Anderson, Clothier, Aberchirder.
C. Wm. Wedderburn, Hatton, Fintray, Aberdeen.

### Class 35. LEGHORN. Cockerel.

1st. L. Anderson, 9 Reform Street, Dunfermline.
2d. The Countess of Aberdeen, Haddo House, Aberdeen.
C. Wm. Keys, Kintore.

### Class 36. LEGHORN. Pullet.

1st. L. Anderson, 9 Reform Street, Dunfermline.
2d. James Gordon, Gas Works, Armadale, Linlithgowshire.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

### Class 37. LANGSHAN. Cock.

1st. John S. Pagan, Coulshill, Auchterarder.
2d. James Forsyth, Falkland, Fifeshire.

### Class 38. LANGSHAN. Hen.

1st. John S. Pagan, Coulshill, Auchterarder.

### Class 39. LANGSHAN. Cockerel.

1st. John S. Pagan, Coulshill, Auchterarder.

### Class 40. LANGSHAN. Pullet.

1st. John S. Pagan, Coulshill, Auchterarder.

### Class 41. WYANDOTTE. Cock.

1st. Thomas Thomson, Coal Staith, Brampton.
2d. Henry Maidment, Lanercost, Brampton, Cumberland.
C. Mrs Kinnaird, Clockmill, Duns.

### Class 42. WYANDOTTE. Hen.

1st. Henry Maidment, Lanercost, Brampton, Cumberland.
2d. John Cran, Old Keith, Keith.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

### Class 43. WYANDOTTE. Cockerel.

1st. The Countess of Aberdeen, Haddo House, Aberdeen.
2d. Mrs Kinnaird, Clockmill, Duns.
C. Henry Maidment, Lanercost, Brampton, Cumberland.

### Class 44. WYANDOTTE. Pullet.

1st. Henry Maidment, Lanercost, Brampton, Cumberland.
2d. D. L. Picken, Milton, Kirkcudbright.
C. The Countess of Aberdeen, Haddo House, Aberdeen.

### Class 45. Any other Pure Breed. Cock.

1st. T. P. Gordon, Prize Poultry Farm, Thornton, Leven (Orpington).
2d. Miss Nicol, Roscobie, Banchory (Orpington).
C. D. L. Picken, Milton, Kirkcudbright (Indian Game).

### Class 46. Any other Pure Breed. Hen.

1st. Mrs D. Mackenzie, Meigle (Spanish).
2d. D. L. Picken, Milton, Kirkcudbright (Indian Game),
C. The Countess of Aberdeen, Haddo House, Aberdeen (Indian Game).

CLASS 47. Any other Pure Breed. Cockerel.

1st. The Countess of Aberdeen, Haddo House, Aberdeen (Indian Game).
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven (Andalusian).
C. Mrs D. Mackenzie, Meigle (Spanish).

CLASS 48. Any other Pure Breed. Pullet.

1st. The Countess of Aberdeen, Haddo House, Aberdeen (Indian Game).
2d. W. H. Sinclair of Newton, Prospect Hill, Aberdeen (Orpington).
C. Mrs D. Mackenzie, Meigle (Spanish).

CLASS 49. GAME—Black or Brown Reds. Cock.

1st. David Wishart, 13 Little Causeway, Forfar.
2d. George Cran, Walbrook, Banchory.
C. George Cran, Walbrook, Banchory.

CLASS 50. GAME—Black or Brown Reds. Hen.

1st. David Wishart, 13 Little Causeway, Forfar.
2d. William A. Gibson, 21 Dundee Loan, Forfar.
C. George Cran, Walbrook, Banchory.

CLASS 51. GAME—Black or Brown Reds. Cockerel.

1st. David Wishart, 13 Little Causeway, Forfar.
2d. George Cran, Walbrook, Banchory.
C. George Cran, Walbrook, Banchory.

CLASS 52. GAME—Black or Brown Reds. Pullet.

1st. David Wishart, 13 Little Causeway, Forfar.
2d. George Cran, Walbrook, Banchory.
C. George Cran, Walbrook, Banchory.

CLASS 53. GAME—Any other Pure Breed. Cock.

1st. William A. Gibson, 21 Dundee Loan, Forfar (Pile).

CLASS 54. GAME—Any other Pure Breed. Hen.

1st. John Cran, Old Keith, Keith (Indian Game).
2d. Alexander Shepherd, 59 Dundee Loan, Forfar (Pile).
C. William A. Gibson, 21 Dundee Loan, Forfar (Pile).

CLASS 55. GAME—Any other Pure Breed. Cockerel.

1st. Robert Scott, 56 Dundee Road, Forfar (Pile).

CLASS 56. GAME—Any other Pure Breed. Pullet.

1st. David Wishart, 13 Little Causeway, Forfar (Pile).

CLASS 57. BANTAM—Any Pure Breed. Cock.

1st. James Duncan, 7 Bell Place, Forfar.
2d. James Duncan, 67 Barron Street, Woodside, Aberdeen.
C. Thomas Scott, South Woodend, Bonnybridge.

CLASS 58. BANTAM—Any Pure Breed. Hen.

1st. D. L. Picken, Kirkcudbright (Sebright).
2d. James Duncan, 67 Barron Street, Woodside, Aberdeen.
C. James Duncan, 7 Bell Place, Forfar (Pile).

CLASS 59. BANTAM—Any Pure Breed. Cockerel.

1st. Thomas Guild, Herdhill Farm, near Kirriemuir (Game).
2d. Peter Morris, 129 Whitemyre, Dunfermline (Game).
C. James Duncan, 7 Bell Place, Forfar.

CLASS 60. BANTAM—Any Pure Breed. Pullet.

1st. Peter Morris, 129 Whytemyre, Dunfermline (Game).
2d. Thomas Guild, Herdhill Farm, near Kirriemuir (Game).
C. James Duncan, 7 Bell Place, Forfar.

CLASS 61. DUCKS—White Aylesbury. Drake.

1st. John Gillies, Edington Mills, Chirnside.
2d. John Gillies, Edington Mills, Chirnside.
C. Miss Blackburn, Killearn, Glasgow.

CLASS 62. DUCKS—White Aylesbury. Duck.

1st. John Gillies, Edington Mills, Chirnside.
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
C. John S. Pagan, Coulshill, Auchterarder.

CLASS 63. DUCKS—White Aylesbury. Drake (Young).

1st. John Gillies, Edington Mills, Chirnside.
2d. Charles G. Meldrum, Manse of Logierait, Ballinluig.
C. Miss Blackburn, Killearn, Glasgow.

CLASS 64. DUCKS—White Aylesbury. Duckling.

1st. John Gillies, Edington Mills, Chirnside.
2d. T. P. Gordon, Prize Poultry Farm, Thornton, Leven.
C. John S. Pagan, Coulshill, Auchterarder.

CLASS 65. DUCKS—Rouen. Drake.

1st. John Cran, Old Keith, Keith.
2d. D. L. Picken, Milton, Kirkcudbright.
C. Thomas Scott, South Woodend, Bonnybridge.

CLASS 66. DUCKS—Rouen. Duck.

1st. John M. Martin, Auchendennan, Balloch.
2d. Thomas Scott, South Woodend, Bonnybridge.
C. Thomas Scott, South Woodend, Bonnybridge.

CLASS 67. DUCKS—Rouen. Drake (Young).

1st. Thomas Scott, South Woodend, Bonnybridge.
2d. John Cran, Old Keith, Keith.
C. D. L. Picken, Milton, Kirkcudbright.

CLASS 68. DUCKS—Rouen. Duckling.

1st. Thomas Scott, South Woodend, Bonnybridge.
2d. John Cran, Old Keith, Keith.
C. D. L. Picken, Milton, Kirkcudbright.

CLASS 69. DUCKS—Any other Pure Breed. Drake.

1st. John Cran, Old Keith, Keith (Pekin).
2d. Lady Wilson, Chillingham Barns, Belford, Northumberland (Cayuga).

CLASS 70. DUCKS—Any other Pure Breed. Duck.

1st. Lady Wilson, Chillingham Barns, Belford, Northumberland (Cayuga).

CLASS 71. DUCKS—Any other Pure Breed. Drake (Young).

1st. George L. Oliver, Whithaugh, Newcastleton (Pekin).
2d. Lady Wilson, Chillingham Barns, Belford, Northumberland (Cayuga).

CLASS 72. DUCKS—Any other Pure Breed. Duckling.

1st. Lady Wilson, Chillingham Barns, Belford, Northumberland (Cayuga).
2d. George L. Oliver, Whithaugh, Newcastleton (Pekin).

CLASS 73. TURKEYS—Any Pure Breed. Cock.

1st. A. Turnbull, Hayston Cottage, near Kirkintilloch (American Bronze).
2d. Lady Wilson, Chillingham Barns, Belford, Northumberland (Bronze).
C. Thomas Scott, South Woodend, Bonnybridge (Bronze).

CLASS 74. TURKEYS—Any Pure Breed. Hen.

1st. Lady Wilson, Chillingham Barns, Belford, Northumberland (Bronze).
2d. Charles G. Meldrum, Manse of Logierait, Ballinluig (American Bronze).
C. John M. Martin, Auchendennan, Balloch (Bronze).

CLASS 75. TURKEYS—Any Pure Breed. Cock (Poult).

1st. Andrew Berwick, Hayston, Leuchars.
2d. George Bell, Downfield, Ladybank (American Bronze).

CLASS 76. TURKEYS—Any Pure Breed. Hen (Poult).

1st. Andrew Berwick, Hayston, Leuchars.
2d. George Bell, Downfield, Ladybank (American Bronze).
C. George F. Barron, Meikle Endovie, Alford (Bronze).

CLASS 77. GEESE—Any Pure Breed. Gander.

1st. James Dow, Clathybeg, Auchterarder (Ebden).
2d. Thomas Scott, South Woodend, Bonnybridge (Toulouse).
C. D. L. Picken, Milton Farm, Kirkcudbright (Toulouse).

CLASS 78. GEESE—Any Pure Breed. Goose.

1st. James Dow, Clathybeg, Auchterarder (Ebden).
2d. James Lawson, Scotsmill, Alford, N.B. (Toulouse).

CLASS 79. GEESE—Any Pure Breed. Gander Young).

1st. James Dow, Clathybeg, Auchterarder (Ebden).
2d. Thomas Scott, South Woodend, Bonnybridge (Toulouse).
C. D. L. Picken, Milton, Kirkcudbright (Toulouse).

CLASS 80. GEESE—Any Pure Breed. Gosling.

1st. Thomas Scott, South Woodend, Bonnybridge (Toulouse).
2d. James Dow, Clathybeg, Auchterarder (Toulouse).
C. D. L. Picken, Milton, Kirkcudbright (Toulouse).

## DAIRY PRODUCE

CLASS 1. CURED BUTTER, not less than 7 lb.—Premiums, £4, £2, and £1.

1st. Alexander Fleming, Threepland, Eaglesham.
2d. Archibald Cullen, Woodend, Airdrie.
3d. William Duncan, Middlerigg, Polmont Station.
V.H.C. George Morton, Kirktonmoor, Eaglesham.
H.C. Robert Gilmour, Stonebyres, Eaglesham.
C. Henry Orr, Torrance Farm, West Craigs.

CLASS 2. POWDERED BUTTER, not less than 7 lb.—Premiums, £4, £2, and £1.

1st. Henry Orr, Torrance Farm, West Craigs.
2d. Archibald Cullen, Woodend, Airdrie.
3d. Robert Gilmour, Stonebyres, Eaglesham.
V.H.C. Alexander Fleming, Threepland, Eaglesham.
H.C. George Morton, Kirktonmoor, Eaglesham.
C. David Longwill, Kendieshill, Linlithgow.

CLASS 3. FRESH BUTTER, Three 1-lb. Rolls.—Premiums, £4, £2, and £1.

1st. George Wallace, Kinglass Farm, Bo'ness, Linlithgow.
2d. George Morton, Kirktonmoor, Eaglesham.
3d. Archibald Cullen, Woodend, Airdrie.
V.H.C. Miss Susie F. Elton, Mansfield, Thornhill, Dumfriesshire.
H.C. Henry Orr, Torrance Farm, West Craigs.
C. Robert Gilmour, Stonebyres, Eaglesham.

## BUTTER-MAKING COMPETITIONS.

(OPEN TO MEN AND WOMEN.)

*Wednesday, 25th July.*

Premiums, £3, £2, and £1.

1st. Susie F. Elton, Mansfield, Thornhill, Dumfriesshire, . . . 93½ points
2d. Miss Morrison, Bush, Rothesay, . . . . . 92 points
3d. Lizzie Lochhead, The Bow, Stow, Mid-Lothian, . . . 90½ points

*Thursday, 26th July.*

Premiums, £3, £2, and £1.

1st. Jean Ramsay Keith, Canisbay House, Canisbay, Caithness, . 95¼ points
2d. Jessie L. M'Kenzie, Holestane, Thornhill, Dumfriesshire, . 94¼ points
3d. Lizzie Horn Smith, 7 Shandon Street, Edinburgh, . . . 93 points

*Friday, 27th July.*

CHAMPION COMPETITION, open only to winners of Prizes on the preceding days. FIRST PRIZE—the Society's Silver Medal; SECOND PRIZE—the Society's Medium Silver Medal.

Equal { Susie F. Elton, Mansfield, Thornhill, / Lizzie H. Smith, 7 Shandon Street, Edinburgh, } Silver Medal, . 95½ points
Lizzie Lochhead, The Bow, Stow, Medium Silver Medal, . . 93¾ points

## HORSE-SHOEING.

(*Prizes given by Sir James H. Gibson-Craig, Bart.*)

OPEN TO SHOEING-SMITHS FROM ANY PART OF SCOTLAND.

*Thursday, 26th July.*

CLASS 1. DRAUGHT HORSES.—Premiums, £3, £2, and £1.

1st. Robert Muir, Fiveways, by Hurlford.
2d. Robert Muir, Sandyford, by Monkton, Ayrshire.
3d. { William Horsburgh, Hermiston, Currie. / John Webster, 42 Loch Street, Aberdeen. }
H.C. George Clarke, Seafield Street, Cullen.
C. John Troup, 30 Carmelite Street, Aberdeen.

*Friday, 27th July.*

CLASS 2. ROADSTERS.—Premiums, £3, £2, and £1.

1st. John Webster, 42 Loch Street, Aberdeen.
2d. John Marshall, Gateside, Beith.
3d. George Sellar, Kilcreggan, Dumbartonshire.
H.C. David Caldwell, 42 Ashvale Place, Aberdeen.
C. Robert Muir, Fiveways, by Hurlford.

# HIGHLAND INDUSTRIES

## KNITTING.

SECTION A, OF S. HOME INDUSTRIES ASSOCIATION.

CLASS 1. Fine White SHETLAND SHAWL (sub-section 2, S.H.I.A.)—Premiums, £2 and 15s.

1st. James Moar, West Shore, Uyasound.
2d. Julia Fraser, Crosbister, Uyasound.
H.C. Robina Anderson, Greenside, Baltasound, Shetland.

CLASS 2. Thick Coloured SHETLAND SHAWL (sub-section 3, S.H.I.A.)—Premiums, £2 and 15s.

1st. Mrs Elizabeth Linklater, Hillhead, Lerwick.
2d. Catherine Gray, Island of Foula.
V.H.C. Mrs Elizabeth Linklater, Hillhead, Lerwick.

CLASS 3. COLLECTION of not less than Five Articles of NATIVE WOOL, hand-spun, home-dyed, and knitted by Exhibitor (sub-sections 1, 4, 5, 6, 7, 8, 9, 10, and 11, S.H.I.A.)—Premiums, £2 and £1.

1st. Willa Flaws.
2d. Jane Gray, Island of Foula.

## STOCKINGS.

SECTION B, OF S. HOME INDUSTRIES ASSOCIATION.

CLASS 4. Six pair STOCKING HOSE, hand-spun, home-dyed, and knitted by Exhibitor,—two pair Plain Ribbed, two pair Fancy, and two pair Diced Tartan (sub-sections 1, 2, 4, and 5, S.H.I.A.)—Premiums, £2 and £1.

1st. Anne Mackenzie, Port Henderson, Gairloch.
2d. Anne Mackenzie, No. 1 Sand, Gairloch.

CLASS 5. Six pair SOCKS of Blackfaced Wool, hand-spun, home-dyed, and knitted by Exhibitor (sub-section 3, S.H.I.A.)—Premiums, £1 and 10s.

1st. Ann MacDonald, 18 Sand, Gairloch, Ross-shire.

CLASS 6. Six pair SOCKS, Cheviot Wool, hand-spun, home-dyed, and knitted by Exhibitor (sub-section 3, S.H.I.A.).—Premiums, £1 and 10s.

*(No Competition.)*

## SPINNING AND WEAVING.

SECTION D, OF S. HOME INDUSTRIES ASSOCIATION.

CLASS 7. Pair of BLANKETS, home-spun, handloom-woven (sub-section 1, S.H.I.A.).—Premiums, £1 and 10s.

1st. Mrs Ross, Rogart.
2d. George M'Iver, Strathconnan, Muir of Ord.

CLASS 8. WEB, not less than 25 yards TWEED, Cheviot Wool, hand-spun, home-dyed, and handloom-woven (sub-section 3 or 7, S.H.I.A.).—Premiums, £2 and £1.

1st. Mrs D. Macleod, Badinscally, Achiltibuie, 25 yards at 4s. 9d. per yard.
2d. Angus Pirie, Birch Cottage, Rogart, 32 yards.

CLASS 9. WEB, not less than 25 yards TWEED, Blackfaced Wool, hand-spun, home-dyed, and handloom-woven (sub-section 3 or 7, S.H.I.A.).—Premiums, £2 and £1.

1st. Angus Pirie, Rogart.
2d. George M'Iver, Strathconnan, Muir of Ord, 25 yards.

CLASS 10. WEB, not less than 25 yards, Light Texture, for Ladies' Dresses, Native Wool, hand-spun, home-dyed, and handloom-woven (sub-section 3, S.H.I.A.).—Premiums, £2 and £1.

1st. Angus Pirie, Rogart.
2d. George M'Iver, Strathconnan, Muir of Ord.

CLASS 11. WEB, not less than 8 yards of SHETLAND TWEED, of Shetland Wool, hand-spun and handloom-woven.—Premiums, £1 and 15s.

1st. Mrs Sutherland.
2d. John Cran, Island of Roe.

CLASS 12. Piece of WINCEY, handloom-woven (sub-section 5, S.H.I.A.)—Premiums, £2 and £1.

*(No award.)*

CLASS 13. Two PLAIDS, Native Wool, hand-spun, home-dyed, and handloom-woven (sub-section 9, S.H.I.A.—Premiums, £2 and £1.

1st. Mrs W. Macleod, Polbain, Achiltibuie.
2d. Mrs K. Mackenzie, Badinscally, Achiltibuie.

CLASS 14. Varieties of YARN, not less than four Cuts, hand-spun, home-dyed, suitable for Stockings (sub-section 12, S.H.I.A.).—Premiums, £1 and 10s.

1st. Anne Mackenzie, Gairloch.
2d. George M'Iver, Strathconnan, Muir of Ord.

CLASS 15. Four Cuts YARN, undyed (for quality), hand-spun, suitable for Blankets (sub-section 11, S.H.I.A.).—Premiums, £1 and 10s.

1st. Mrs Ferries, Raemoir Smithy, Banchory.
2d. Mrs M'Lean, Mill Street, Ullapool.

CLASS 16. LINENS (sub-section 14, S.H.I.A.).—Premiums, £2 and £1.

*(Not forward.)*

## FISHING AND GARDENING.

### SECTION I, OF S. HOME INDUSTRIES ASSOCIATION.

CLASS 17. BOX for Carriage of Fish to Market.—Premiums, £1 and 10s.

*(No entry.)*

CLASS 18. Collection of Trout and Salmon FLIES, home-made.—Premiums, £1, 10s. and 10s.

1st. W. Palmer, Oathlaw.
2d. W. Isherwood, Methlick.

CLASS 19. FISHING-RODS and REELS (sub-section 11, S.H.I.A.)—Premiums, £1 and 10s.

1st. A. M'Pherson, Lathermuir. } equal.
1st. James Wishart, Marykirk. }
2d. W. Hutcheson, Methlick.

CLASS 20. NETS, Fishing, or any other kind (sub-section 10, S.H.I.A.).—Premiums, £1 and 10s.

*(No entry.)*

CLASS 21. BASKETS for Garden, Farm, or Fishing Purposes (sub-section 9, S.H.I.A.).—Premiums, £1 and 15s.

1st. Wm. Main, Newtonhill.
2d. A. Ritchie, Torphins.

## JUDGES.

Shorthorn.—R. Stratton, The Duffryn, Newport, Mon.; John Cran, Kirkton, Bunchrew, Inverness.

Aberdeen-Angus.—C. Macpherson Grant of Drumduan, Forres; Arthur J. Owen, Talbotstown, Brittas, *viâ* Dublin.

Galloway.—William Stroyan, Culcraigie, Twynholm, N.B.; Samuel Thomson, Home Farm, Lanrick Castle, Doune.

Highland.—John M'Gillivray, Ballachroan, Kingussie; John Campbell, Calvine, Perthshire.

Ayrshire.—John Murray, jun., Carston, Ochiltree.

Fat Cattle.—William Wallace, Chapel of Seggat, Auchterless.

Stallions and Entire Colts.—Abram Kerr, Castlehill, Durisdeer; James F. Murdoch, East Hallside, Newton.

Mares and Fillies.—James M'Allister, Meikle Kilmory, Rothesay; David A. Hood, Balgreddan, Kirkcudbright.

Hunters and Roadsters.—J. M'Kie, Ernespie, Castle-Douglas; A. Alexander, Cockburnhill, Balerno.

Hackneys and Ponies.—Christopher W. Wilson, Rigmaden Park, Kirby-Lonsdale.

Shetland Ponies.—John M. Martin of Auchendennan, Alexandria, N.B.

Blackfaced.—Duncan M'Diarmid, Camusericht, Rannoch, N.B.; Thomas Elliot, Blackhaugh, Galashiels.

Cheviot.—John Miller of Scrabster, Thurso.

Border Leicesters.—L. C. Chrisp, Hawkhill, Alnwick; Alexander Simpson, Duff House, Banff.

Shropshire.—Joseph Beach, The Hattons, Wolverhampton.

Fat Sheep.—James White, Market Buildings, Aberdeen.

Poultry.—William Anderson, Whinnie Knowe, Nairn.

Butter and Butter-Making Competitions.—R. J. Drummond, Kilmarnock.

Horse-Shoeing.—Principal Williams, New Veterinary College, Edinburgh.

## ATTENDING MEMBERS.

Shorthorn.—Thomas Gordon Duff of Drummuir; Dr Profeit, Ballater; A. R. Stuart of Inverfiddich; William Duthie, Collynie.

Aberdeen-Angus.—George J. Walker, Portlethen; A. F. Leslie, Montcoffer House; Ranald Macdonald, Cluny Castle.

Galloway.—Andrew Mackenzie, Dalmore; John Wilson, Castle Park; James Campbell, Cullen House.

Highland.—Sir Robert Menzies of Menzies, Bart.; Charles T. Gordon of Cairness; Baillie Edwards, Aberdeen.

Ayrshire.—John Speir, Newton Farm; Robert Copland, Milton of Ardlethen; Alexander Keith, Chapelton; Andrew Allan.

Fat Cattle.—W. S. Ferguson, Pictonhill; W. S. Marr, Uppermill; William Falconer, Cairnton.

Stallions and Entire Colts.—R. Sinclair Scott, Burnside; William Duthie, Tarves; William Paterson, Auldtown of Carnoustie; George A. Ferguson, Lessendrum; Colonel Smith, Minmore.

Mares and Fillies.—John Balingall, Dunbog; J. M. Morton Campbell, yr. of Stracathro; James Smith, Pittengardner; John Sleigh, Strichen Mains; F. H. Forbes Irvine of Drum.

Hunters and Roadsters.—George Dun, Easter Kincaple; C. M. Cameron, Balnakyle; Sir Thomas Burnett of Leys, Bart.; Sir Arthur Grant of Monymusk, Bart.; Robert Garden, Mains of Tolquhon; James Wyllie, Edinburgh.

HACKNEYS AND PONIES.—David Wilson, yr. of Carbeth; James Hay, Little Ythsie; P. M. Turnbull, Smithston; George Wilken, Waterside of Forbes.

SHETLAND PONIES.—W. H. Lumsden of Balmedie; Capt. H. F. Lindsay Carnegie of Kimblelethmont; Ex-Bailie Pyper; John Macpherson, Mulben.

BLACKFACED.—George Cowe, Balhousie; Garden A. Duff, Hatton Castle; James Cochrane, Waterside Lodge; Colonel G. S. Grant, Auchorachan; James Wilson, Inchgower.

CHEVIOT.—R. Shirra Gibb, Boon; William Nicoll, Hilton of Fearn; David Reid, Crofts of Glenmuick.

BORDER LEICESTER.—John Scott Dudgeon, Longnewton; P. Chalmers, Aldbar Castle; A. M. Ogilvy, Tillynaught.

SHROPSHIRES.—W. T. Malcolm, Dunmore; A. F. Nares, Parkhill; P. M. Cran, Aberdeen.

FAT SHEEP.—Alexander Cross of Knockdon; James Bruce, Collithie; James Thomson, Balbegno.

POULTRY.—Robert Paterson, Hill of Drip; Bailie Henderson, Aberdeen; A. Wilkie, Aberdeen.

BUTTER AND BUTTER-MAKING.—Bailie Mearns, Aberdeen; John Hart, Cowie House; J. M. E. Scott.

HORSE-SHOEING.—John Marr, Cairnbrogie; Robert Paterson, Hill of Drip; Lieut.-Colonel Innes, yr. of Learney, R.N., R.A.; George Bruce, Tochineal.

## II.—DISTRICT COMPETITIONS.

### CATTLE, HORSES, AND SHEEP.

| NAME OF DIST. | PREMIUM AWARDED TO | FOR | AMOUNT. |
|---|---|---|---|
| *Argyll* | Arch. Turner, Kilchamaig | Highland Bull | £1 10 0 |
| | J. Campbell of Kilberry | do. Cow | 1 10 0 |
| | B. & J. Mundell, Achnacarnan | Ayrshire Bull | 1 10 0 |
| | B. & J. Mundell, Achnacarnan | do. Cow | 1 10 0 |
| | G. Hamilton, Crear | Blackfaced Shearling Tup | 1 10 0 |
| | Sir John Orde of Kilmory, Bart. | do. Ewes | 1 10 0 |
| | C. G. P. Campbell of Stonefield | Clydesdale Mare | 1 10 0 |
| | Capt. Stewart of Knockrioch | do. Filly | 1 10 0 |
| *Carrick* | Quinton Dunlop, Morriston | Blackfaced Tup | 4 0 0 |
| | Henry M'Fadzean, Ashfield | Ayrshire Bull | 4 0 0 |
| | J. G. M'Cubbin, Maybole | Hunter Gelding | 4 0 0 |
| *Morayshire* | Colonel Smith, Minmore | Shorthorn Bull | 3 0 0 |
| | A. W. Law, Mains of Sanquhar | do. | 1 10 0 |
| | Wm. Robertson, Linkwood | Shropshire Tup | 3 0 0 |
| | Jas. M'William, Stoneytown | Leicester Tup | 1 10 0 |
| | James Brander, Pittendreich | Large White Boar | 2 0 0 |
| | James Brander, Pittendreich | Berkshire Sow | 1 0 0 |
| *Kinglassie* | J. & W. Meiklem, Begg | Draught Brood Mare | 1 0 0 |
| | Geo. Bennett, S. Pitkinnie | do. Yeld Mare | 1 0 0 |
| | J. &. W. Meiklem, Begg | do. Filly | 1 0 0 |
| | John Paton, Kirkness | do. | 0 10 0 |
| | J. & W. Meiklem, Begg | do. | 0 10 0 |
| | | Carry forward | £40 0 0 |

| NAME OF DIST. | PREMIUM AWARDED TO | FOR | AMOUNT. |
|---|---|---|---|
| | | Brought forward | £40 0 0 |
| *Kinglassie —cont.* | John Paton, Kirkness | Aberdeen-Angus Bull | 1 0 0 |
| | Thos. Goodall, Cardenbarns | Shorthorn Bull | 1 0 0 |
| | James Inglis, Redhouse | do. Cow | 1 0 0 |
| | James Inglis, Redhouse | do. Heifer | 0 10 0 |
| | Alex. Heatherwick, N. Bogside | do. | 0 10 0 |
| | John Paton, Kirkness | Leicester Tup | 1 0 0 |
| | Wm. Gibb, Arnott Mill | do. Shearling Tup | 1 0 0 |
| | J. &. A. Goodall, Balgreggie | do. Ewes | 0 15 0 |
| | J. & W. Meiklem, Begg | do. Gimmers | 0 15 0 |
| | Wm. Tod, E. Brackley | Blackfaced Ewes | 0 10 0 |
| *Forth* | John Lawson, Guildhouse | Ayrshire Cow | 1 10 0 |
| | James Hamilton, Woolfords | do. | 1 0 0 |
| | James Hamilton, Woolfords | do. | 0 10 0 |
| | William Hamilton, Shawgill | Ayrshire Bull | 1 10 0 |
| | James Wilson, Mosshat | do. | 1 0 0 |
| | Mrs Padkin, Cleugh Farm | do. | 0 10 0 |
| | John Steele, Summerside | Clydesdale Gelding | 1 10 0 |
| | James Prentice, Bellstane | do. Filly | 1 0 0 |
| | John Dick, Benthead | do. | 0 10 0 |
| | James Hamilton, Woolfords | Blackfaced Tup | 1 10 0 |
| | James Smith, Mountainblow | do. | 1 0 0 |
| | James Hamilton, Woolfords | do. | 0 10 0 |
| *Weem* | Duncan Macdonald, Comrie Farm | Brood Mare | 1 0 0 |
| | Sir Donald Currie, M.P., Garth Castle | Draught Filly | 1 0 0 |
| | Alex. Robertson, Haugh of Ballechin | do. Gelding | 1 0 0 |
| | Charles Munro, Mains of Murthly | Shorthorn Cow | 1 0 0 |
| | Alex. Robertson, Haugh of Ballechin | do. Heifer | 1 0 0 |
| | Alex. Robertson, Haugh of Ballechin | do. | 1 0 0 |
| | Marquis of Breadalbane, K.G. | Highland Cow | 1 0 0 |
| | Sir Donald Currie, M.P., Garth Castle | do. Heifer | 1 0 0 |
| | Sir Donald Currie, M.P., Garth Castle | do. | 1 0 0 |
| | John Scott, Glenlyon House Farm | Aberdeen-Angus Cow | 1 0 0 |
| | Sir Robert Menzies of Menzies, Bart. | do. Heifer | 1 0 0 |
| | John Scott, Glenlyon House Farm | do. | 1 0 0 |
| *Spey, Avon, and Fiddochside* | Col. John Gordon Smith of Delnabo | Shorthorn Cow | Minor Silver Medal |
| | Sir Geo. Macpherson Grant of Ballindalloch, Bart. | Aberdeen-Angus Cow | do. |
| | James Sutor, Collie | Leicester Shearling Tup | do. |
| *Jed-Forest* | W. L. Johnstone, Oxnam Nook | Brood Mare | do. |
| | J. A. W. Mein of Hunthill | Half-bred Ewes | do. |
| | Wm. Tait, Belford | Cheviot Gimmer | do. |
| *Central Banffshire* | Col. Smith Grant, Auchorachan | Aberdeen-Angus Bull | do. |
| | Alex. Mennie, Brawlandknowes | Clydesdale Filly | do. |
| | William Wilson, Coynachie | Blackfaced Tup and Ewe | do. |
| | | Carry forward | £72 0 0 |

| NAME OF DIST. | PREMIUM AWARDED TO | FOR | | AMOUNT. |
|---|---|---|---|---|
| | | Brought forward | | £72 0 0 |
| *Strathspey* | John Grant, Advie Mains | Aberdeen-Angus Bull | Minor Silver Medal. | |
| | D. G. Grant, Gallovie | Draught Mare . | do. | |
| | D. G. Lawson, Achnagallen | Blackfaced Tup . | do. | |
| *West Linton* | John Murray, Leithen Water | Cheviot Shearling Tup | do. | |
| | John Elliot, Meigle | Cheviot Ewes . | do. | |
| | John Elliot, Meigle | Cheviot Gimmers . | do. | |
| *Islay, Jura, and Colonsay* | John Dunlop, Laggan | Clydesdale Stallion | do. | |
| | Charles Morrison of Islay | Highland Cow . | do. | |
| | Wm. Kerr, Corrary | Ayrshire Cow . | do. | |
| *West Teviotdale* | James Moffat, Craik | Cheviot Tup . . | do. | |
| | Miss M. F. Grieve, Skelfhill | Cheviot Shearling Tup | do. | |
| | James Moffat, Craik | Cheviot Ewes . | do. | |
| *Lauderdale* | Marquis of Londonderry, K.G. | Stallion . . . . . . | | 15 0 0 |
| *Northern District of Kincardineshire* | W. A. Lumsden of Balmedie | Stallion . . . . | | 15 0 0 |
| *Orkney Society* | Orkney Horse-Breeding Society | Stallion . . . . . . | | 15 0 0 |
| *Strathearn Central* | P. & W. Crawford, Dumfries | Stallion . . . . | | 15 0 0 |
| | | | | £132 0 0 |
| | | 21 Minor Silver Medals . . . . . | | 5 12 0 |
| | | | | £137 12 0 |

## SPECIAL GRANTS.

| | | |
|---|---|---|
| *Ayrshire Agricultural Association* | Vote to Dairy Produce Show at Kilmarnock | £20 0 0 |
| *Shetland Agricultural Society* | Vote in aid of Premiums . . | 5 0 0 |
| *Orkney Agricultural Society* | do. do. . . | 3 0 0 |
| | | £28 0 0 |

## MEDALS IN AID OF PREMIUMS GIVEN BY LOCAL SOCIETIES.

Minor Silver Medals were awarded to the following:—

### ABERDEENSHIRE.

| NAME OF DIST. | SILVER MEDAL AWARDED TO | FOR |
|---|---|---|
| *Aberdour* | William F. Gordon, Broomhills | Shorthorn Bull |
| | James Milne, Pittendrum | Clydesdale Mare |
| *Ebrieside* | John Wilken, Littletack | Clydesdale Mare |
| | John Grant, Methlick | Aberdeen-Angus Cow |
| *Kennethmont* | Major Gordon, Culdrain | Aberdeen-Angus Heifer |
| | William Milne, Overhall | Clydesdale Filly |
| *Inverurie* | Captain Fraser of Williamston | Aberdeen-Angus Heifer |
| | John Marr, Cairnbrogie | Clydesdale Filly |

### ARGYLLSHIRE.

| NAME OF DIST. | SILVER MEDAL AWARDED TO | FOR |
|---|---|---|
| *Ardnamurchan, Moidart, and Salen* | Robert D. Colthart, Achateny | Blackfaced Sheep |
| | Lach. M'Donald, Kilchoan | Highland Cow and Heifer |
| *Dunoon* | Mrs Jane Lamont, Killellan | Ayrshire Bull |
| | Robert M'Kay, Auchafour | Ayrshire Cow |

### AYRSHIRE.

| | | |
|---|---|---|
| *Ardrossan* | A. Y. Allan, Munnoch | Ayrshire Heifer |
| | James Howie, jun., Hillhouse | Clydesdale Mare |
| *Beith* | James Kerr, Sidehouse | Ayrshire Cow |
| | Thomas Kennedy, South Nettlehirst | Clydesdale Mare |
| *Girvan* | John Barbour, Alticane | Ayrshire Bull |
| | William Kerr, Houdston | Clydesdale Mare |
| *Monkton, Newton, &c.* | John Stevenson, Ladykirk | Ayrshire Cow |
| | J. A. Campbell of Craigie | Clydesdale Mare |
| *West Kilbride* | John Crawford, Milstonford | Ayrshire Cow |
| | Thomas Simpson, Yonderfield | Clydesdale Brood Mare |
| *New Cumnock* | John Alexander, Dykes | Clydesdale Mare |
| | William Steele, Fardenreoch | Ayrshire Cow |

### BERWICKSHIRE.

| | | |
|---|---|---|
| *Lauderdale Bee-keepers* | George Scott, Boghall | Non-Sectional Super |
| | Helen Robertson, Kirkton Hill | Super in Straw |

### DUMFRIESSHIRE.

| | | |
|---|---|---|
| *Moffat and Upper Annandale* | Adam Calder, Blackhouse | Blackfaced Tup |
| | John Fraser, Little Gala | Ayrshire Heifer |

### KIRKCUDBRIGHTSHIRE.

| | | |
|---|---|---|
| *Carsphairn* | W. A. M'Turk, Barlae | Blackfaced Sheep |
| | Mrs Laidlaw, Marscalloch | Fresh Butter |

### NAIRNSHIRE.

| | | |
|---|---|---|
| *Nairnshire Ornithological* | Alexander Fraser, White Bridge | Plymouth Rock Cockerel |
| | William Stephen, Nairn | Hamburg Hen |

### PEEBLESSHIRE.

| | | |
|---|---|---|
| *Upper Tweedside* | Wm. J. Murray, Dalwyck Mill | Blackfaced Tup |
| | Sir G. Graham Montgomery of Stanhope, Bart. | Cheviot Tup |

### PERTHSHIRE.

| | | |
|---|---|---|
| *Moulin* | John M'Lauchlan, West Haugh | Green Crop |

### ROSS-SHIRE.

| | | |
|---|---|---|
| *Northern Pastoral* | R. C. Munro-Ferguson of Novar, M.P. | Blackfaced Tup |
| | R. C. Munro-Ferguson of Novar, M.P. | Blackfaced Shearling Tup |

### ROXBURGHSHIRE.

| | | |
|---|---|---|
| *Liddesdale* | John Elliot, West Middles | Clydesdale Gelding |
| | John T. Dodd, Riccarton | Cheviot Ewes |
| *Roxburghshire Bee-keepers* | George Cumming, Langholm | Bee Furniture and Appliances |
| | Harry Wood, Paradise Apiaries | Clover Honey |

11 Minor Silver Medals, £10, 18s. 8d.

### PLOUGHING COMPETITIONS.

In 1893-94 the Society's Silver Medal was awarded at 210 Ploughing Competitions.

210 Minor Silver Medals, £56.

## IV.—COTTAGES AND GARDENS.

| | |
|---|---|
| Money Premiums | £6 0 0 |
| 26 Minor Silver Medals | 6 18 8 |
| Total | £12 18 8 |

## V.—VETERINARY DEPARTMENT.

### CLASS EXAMINATIONS—1894.

Silver Medals were awarded to the following:—

ROYAL (DICK) VETERINARY COLLEGE.

| | | | |
|---|---|---|---|
| Ainsworth Wilson | Vet. Med. & Hygiene | George Moir | Physiology |
| Ainsworth Wilson | Cattle Pathology & Meat Inspection | George Green | Pathology |
| George Green | Veterinary Obstetrics | W. H. Murgatroyd | Chemistry |
| Ainsworth Wilson | Materia Medica | J. L. Frood | Botany |
| W. E. Ison | Senior Anatomy | Alf. Holburn | Parasitology |

NEW VETERINARY COLLEGE, EDINBURGH.

| | | | |
|---|---|---|---|
| R. C. Moore | Path. of the Horse | R. C. Cochrane | Junior Anatomy |
| J. L. Sarr | Path. of the Ox | J. B. Collyer | Chemistry |
| J. E. Mills | Physiology | W. M. Ogilvy | Botany |
| Thomas Dick | Senior Anatomy | T. R. Mulcahy | Best Practical |

GLASGOW VETERINARY COLLEGE.

| | | | |
|---|---|---|---|
| D. Walker | Junior Anatomy | M. White | Medicine and Surgery (Cattle), written |
| J. Marshall | Chemistry | T. C. Ferguson | Materia Medica (written) |
| J. Marshall | Botany | M. White | Pathology |
| John Raphael M'Call | Zoology | J. M'Neil | Senior Anatomy |
| H. J. Maxfield | Medicine & Surgery (Horse), written | J. M'Neil | Physiology |

28 Large Silver Medals, £19, 12s.

## VI.—AGRICULTURAL CLASS, EDINBURGH UNIVERSITY.

| | |
|---|---|
| D. F. Chalmers, Camregan, Girvan | £5 0 0 |
| Herbert S. Daine, Woolfall Hall Farm, Huyton, Liverpool | 5 0 0 |
| | £10 0 0 |

## ABSTRACT OF PREMIUMS.

| | | |
|---|---|---|
| 1. ABERDEEN SHOW . . . . . . . . . . . | | £2121 1 3 |
| 2. DISTRICT SHOWS:— | | |
| Stock . . . . . . . . . . . | £137 12 0 | |
| Special Grants . . . . . . . . | 28 0 0 | |
| Local Societies—41 Medals . . . . . . | 10 18 8 | |
| Ploughing Associations—210 Medals . . . | 56 0 0 | |
| | | 232 10 8 |
| 3. COTTAGES AND GARDENS—Money Premiums, £6; 26 Minor Silver Medals, £6, 18s. 8d. . . . . . . . . . . | | 12 18 8 |
| 4. VETERINARY DEPARTMENT—Medals to Students . . . . | | 19 12 0 |
| 5. AGRICULTURAL CLASS, EDINBURGH UNIVERSITY . . . . | | 10 0 0 |
| | | £2396 2 7 |

# STATE OF THE FUNDS

OF

# THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

**At 30th NOVEMBER 1894.**

| | | | |
|---|---|---|---|
| I. HERITABLE BONDS— | | | |
| £11,000 at 4¼ per cent, £1,300 at 4 per cent, £2,500 at 3¾ per cent, £850 at 3½ per cent, £4,000 at 3¼ per cent | | | £19,650 0 0 |
| II. DEBENTURE STOCKS— | | | |
| £4,250 North British Railway Company 3 per cent, at £106¾ | | £4,520 18 9 | |
| £2,727 Caledonian Railway Company 4 per cent, at £143 | | 3,899 12 2 | |
| £1,334 London and North-Western Railway Company 3 per cent, at £111 | | 1,480 14 9 | |
| | | | 9,901 5 8 |
| III. BANK STOCKS— | | | |
| £6,407 7 8 | Royal Bank of Scotland, at £227 | £14,544 15 2 | |
| 2,218 16 | Bank of England, at £332 | 7,366 9 8 | |
| 2,500 0 0 | British Linen Company Bank, at £390 | 9,750 0 0 | |
| 1,250 0 0 | National Bank of Scotland, at £343 | 4,287 10 0 | |
| 1,080 0 0 | Commercial Bank of Scotland (equivalent to 54 shares of £100 each, £20 paid), at £68, 10s. per share of £20 paid | 3,699 0 0 | |
| 1,741 13 4 | Bank of Scotland, at £332 | 5,782 6 8 | |
| £15,197 17 5 | | | 45,130 1 6 |

*Note*.—The original cost of these Bank Stocks was £26,012, 3s. 4d., showing a profit, at present prices, of £19,417, 18s. 2d.

| | |
|---|---|
| IV. DEPOSIT RECEIPT with Royal Bank of Scotland, dated 8th February 1894 | 800 0 0 |
| V. ESTIMATED VALUE of Building, No. 3 George IV. Bridge | 3,100 0 0 |
| VI. ESTIMATED VALUE of Furniture, Paintings, Books, &c. | 1,000 0 0 |
| VII. ARREARS OF MEMBERS' SUBSCRIPTIONS considered recoverable | 70 19 6 |
| VIII. BALANCE DUE BY ROYAL BANK OF SCOTLAND ON ACCOUNT CURRENT, at 30th November 1894 | 277 10 8 |
| AMOUNT OF GENERAL FUNDS | £80,229 17 4 |
| IX. TWEEDDALE MEDAL FUND— | |
| Heritable Bond, at 3¾ per cent | £500 0 0 |

W. S. WALKER, *Treasurer*.
JAS. H. GIBSON-CRAIG, *Member of Finance Committee*.
WM. HOME COOK, C.A., *Auditor*.

EDINBURGH, 9*th January* 1895.

# VIEW OF THE INCOME AND EXPENDITURE
## For the Year 1893-94.

### INCOME.

| | | | |
|---|---|---|---|
| 1. | ANNUAL SUBSCRIPTIONS AND ARREARS received | | £846 10 0 |
| 2. | LIFE SUBSCRIPTIONS | | 936 5 6 |
| | | | £1,782 15 6 |
| 3. | INTERESTS AND DIVIDENDS received— | | |
| | Interests | £959 4 3 | |
| | Dividends | 1,721 11 5 | |
| | | | 2,680 15 8 |
| 4. | TRANSACTIONS | | 56 13 2 |
| 5. | SUM received from Government in aid of Expenses of Agricultural Experiments | | 200 0 0 |
| 6. | RECEIPTS from Aberdeen Show | | 8,544 15 6 |
| | SUM OF INCOME | | £13,264 19 10 |

### EXPENDITURE.

| | | | | |
|---|---|---|---|---|
| 1. | ESTABLISHMENT— | | | |
| | Salaries and Wages | | £1,010 15 0 | |
| | Feu-duty, Taxes, Coals, Gas, Insurance, Repairs and Furnishings | | 129 9 4 | |
| | | | £1,140 4 4 | |
| 2. | FEE TO AUDITOR of Accounts for 1892-93 | | 50 0 0 | |
| 3. | FEE TO PRACTICAL ENGINEER | | 20 0 0 | |
| 4. | AGRICULTURAL EDUCATION (including Fees to Examiners) | | 55 13 0 | |
| 5. | CHEMICAL DEPARTMENT | | 728 3 6 | |
| 6. | VETERINARY DEPARTMENT | | 45 17 0 | |
| 7. | BOTANICAL DEPARTMENT | | 25 0 0 | |
| 8. | SPECIAL GRANTS | | 130 0 0 | |
| 9. | TRANSACTIONS | | 431 16 9 | |
| 10. | ESSAYS AND REPORTS | | 133 3 0 | |
| 11. | ORDINARY Printing, Advertising, Stationery, Postages, and Bank Charges | | 217 6 8 | |
| 12. | SUBSCRIPTIONS to Public Societies | | 25 0 0 | |
| 13. | PAYMENTS in connection with Edinburgh Show— | | | |
| | Premiums | £132 10 0 | | |
| | Sundries | 139 2 6 | | |
| | | | 271 12 6 | |
| 14. | MISCELLANEOUS | | 130 6 6 | |
| 15. | ABERDEEN SHOW— | | | |
| | Premiums paid | £1,997 10 6 | | |
| | General Expenses, as per Abstract, p. 521 | 4,745 0 11 | | |
| | | | 6,742 11 5 | |
| 16. | PREMIUMS for District Competitions | | 312 4 4 | |
| | SUM OF EXPENDITURE | | | 10,458 19 0 |
| | BALANCE OF INCOME | | | £2,806 0 10 |

W. S. WALKER, *Treasurer.*
JAS. H. GIBSON-CRAIG, *Member of Finance Committee.*
WM. HOME COOK, C.A., *Auditor.*

EDINBURGH, *9th January* 1895.

## ABSTRACT of the ACCOUNTS of the HIGHLAND and

### *CHARGE.*

| | | | | |
|---|---|---|---|---|
| 1. BALANCE due by Royal Bank of Scotland on Account Current at 30th November 1893 . . . . . . | | | | £771 9 10 |
| 2. ARREARS of Subscriptions outstanding at 30th Nov. 1893 . . . . . . | | | £61 19 0 | |
| Whereof due by Members who have compounded for life, and are thereby extinguished . . | | £9 3 6 | | |
| Sums ordered to be written off . | | 29 11 6 | | |
| | | | 38 15 0 | |
| | | | | 23 4 0 |
| 3. INTERESTS AND DIVIDENDS— | | | | |
| (1) Interest on Heritable Bonds, less Income-tax | | | £687 17 11 | |
| (2) Interest on Debenture Stock, do. | | | 267 17 9 | |
| (3) Interest on Deposit Receipt, p. £400, dated 17th April, and uplifted 12th November 1894 | | | 3 8 7 | |
| | | | £959 4 3 | |
| (4) Dividends on Bank Stocks— | | | | |
| Royal Bank of Scotland . | £6,407 7 8 | £576 13 2 | | |
| Bank of England | 2,218 16 5 | 188 11 11 | | |
| British Linen Co. Bank . . | 2,500 0 0 | 375 0 0 | | |
| National Bank of Scotland . | 1,250 0 0 | 187 10 0 | | |
| Commercial Bank of Scotland . | 1,080 0 0 | 167 8 0 | | |
| Bank of Scotland . . | 1,741 13 4 | 226 8 4 | | |
| | £15,197 17 5 | | 1,721 11 5 | |
| | | | | 2,680 15 8 |
| 4. SUBSCRIPTIONS— | | | | |
| Annual Subscriptions . . . . . | | | £943 15 0 | |
| Life Subscriptions . . . . . . | | | 936 5 6 | |
| | | | | 1,880 0 6 |
| 5. TRANSACTIONS—Sales, £11, 4s. 2d.; Advertisements, £45, 9s. . | | | | 56 13 2 |
| 6. SUM received from Government in aid of Expenses of Agricultural Experiments . . . . . . . . | | | | 200 0 0 |
| 7. RECEIPTS from Aberdeen Show . . . . . | | | | 8,544 15 6 |
| SUM OF CHARGE . . | | | | £14,156 18 8 |

EDINBURGH, 9*th January* 1895.

## AGRICULTURAL SOCIETY of SCOTLAND for the Year 1893-94.

### *DISCHARGE.*

| | | |
|---|---|---|
| 1. Establishment Expenses— | | |
| Salaries and Wages | | £935 15 0 |
| Retiring Allowance to late Clerk, for half-year to 1st April 1894 | | 75 0 0 |
| Feu-duty, £28; Water Rates, £2, 3s. 4d.; Taxes, £36, 2s. 1d. | | 66 5 5 |
| Coals and Firewood, £16, 17s.; Gas, £9, 2s.; Insurance, £8, 14s. 8d. | | 34 13 8 |
| Repairs and Furnishings | | 28 10 3 |
| | | £1,140 4 4 |
| 2. Fee to Auditor of Accounts for year 1892-93 | | 50 0 0 |
| 3. Fee to Practical Engineer for year to 30th June 1894 | | 20 0 0 |
| 4. Agricultural Education—Prizes to Class, £10; Fees to Examiners, Expenses, and Luncheons, £45, 13s. | | 55 13 0 |
| 5. Chemical Department— | | |
| Salary to Chemist, £200; Allowance for Expenses, £200 | £400 0 0 | |
| District Experiments—Manures, &c., £159, 16s. 8d.; Experimenters' Expenses, £18, 1s. 4d. | 177 18 0 | |
| Grants to Analytical Associations | 133 5 0 | |
| Printing | 17 0 6 | |
| | | 728 3 6 |
| 6. Veterinary Department—Fee to Professor Williams, £26, 5s.; Medals to Students, £19, 12s. | | 45 17 0 |
| 7. Botanical Department—Fee to Botanist for year | | 25 0 0 |
| 8. Special Grants—Vote to Scottish Dairy Institute, £60; Vote to Angus and Mearns Dairy School, £20; Vote to Chair of Forestry in Edinburgh University, £50 | | 130 0 0 |
| 9. Society's Transactions—Printing, £264, 5s.; Binding and Postage, £141, 8s. 3d.; Blocks and Electros, £24, 1s. 6d.; Delivering, £2, 2s. | | 431 16 9 |
| 10. Essays and Reports | | 133 3 0 |
| 11. Ordinary Printing and Lithographing, £57, 6s. 8d.; Advertising, £26, 10s. 3d.; Stationery, Books, and Binding, £60, 14s. 11d.; Postage and Receipt Stamps, £66; Bank and Post-Office Charges and Telegrams, £6, 15s. 8d. | | 217 6 8 |
| 12. Subscriptions to Public Societies—Scottish Meteorological Society, £20; Society for Prevention of Cruelty to Animals, £5 | | 25 0 0 |
| 13. Payments in connection with Edinburgh Show—Premiums paid, £132, 10s.; New Entrance Gate, £129, 5s.; Taxes, £7, 15s. 6d.; Expenses in connection with Block Test Competition, £2, 2s. | | 271 12 6 |
| 14. Investments made—£3700; less realised, £400 | | 3,300 0 0 |
| 15. Miscellaneous Expenses—Expenses of Deputation to London regarding Fraudulent Sale of Foreign Meat, £31, 17s.; Secretary's Expenses visiting Shows, £14, 15s. 6d.; Secretary's Expenses attending District Meetings, £20, 15s.; Reporting Meetings, £21; Luncheons to Directors, £16, 6s.; Tods, Murray, & Jamieson, W.S., Business Account in connection with Investments, £4, 4s.; Storing Turnstiles and Indicators, £6, 10s.; Repairing Turnstiles, £9; Handsels, £1, 10s.; Telegraphic Address, £1, 1s.; Restriking Medal, 2s. | | 130 6 6 |
| 16. Aberdeen Show— | | |
| Premiums | £1,997 10 6 | |
| General Expenses, as per Abstract, p. 521 | 4,745 0 11 | |
| | | 6,742 11 5 |
| 17. Premiums for District Competitions | | 312 4 4 |
| 18. Arrears of Subscriptions struck off as irrecoverable | | 40 9 6 |
| 19. Arrears outstanding at 30th November 1894 | | 70 19 6 |
| 20. Balance due by Royal Bank of Scotland on Account Current at 30th November 1894 | | 277 10 8 |
| Sum of Discharge | | £14,156 18 8 |

W. S. WALKER, *Treasurer.*
JAS. H. GIBSON-CRAIG, *Member of Finance Committee.*
WM. HOME COOK, C.A., *Auditor.*

## ABSTRACT of the ACCOUNTS

### CHARGE.

| | | | |
|---|---|---|---|
| 1. Local Subscriptions— | | | |
| Counties of Aberdeen, Banff, Kincardine, and Eastern Division of Forfar | | £780 2 2 | |
| Town Council of Aberdeen | | 100 0 0 | |
| | | | £880 2 2 |
| 2. Amount Collected during Show— | | | |
| Drawn at Gates | £4,071 8 0 | | |
| Drawn at Parades | 763 19 0 | | |
| Catalogues and Awards sold | 281 9 1 | | |
| Lavatory and Directors' Cloak-Room | 4 3 3 | | |
| Drawn at Royal Pavilion | 14 19 0 | | |
| | | | 5,135 18 4 |
| 3. Forage and Manure Sold | | | 13 18 6 |
| 4. Rent of Stalls | | | 1,798 10 6 |
| 5. Rent of Refreshment Booths | | | 250 0 0 |
| 6. Fines for Non-Exhibition of Live Stock | | | 29 13 0 |
| 7. Income from Tweeddale Medal Fund | | | 18 3 3 |
| 8. Advertising in Catalogue and Premium List | | | 141 4 4 |
| 9. Special Prizes Contributed | | | 222 10 0 |
| 10. Contributions for Evening Jumping Prizes | | | 24 0 0 |
| 11. Produce from Working Dairy Sold | | | 4 13 5 |
| 12. Drawn at Exhibition of Binders | | | 8 3 0 |
| 13 Interest from Royal Bank | | | 17 19 0 |
| | | | £8,541 15 6 |

| | |
|---|---|
| *Note.*—From the above balance of | £1802 4 1 |
| There has to be deducted the premiums undrawn at 30th November 1894, amounting to | 123 10 0 |
| Making the probable Surplus | £1678 14 1 |

Edinburgh, 9*th January* 1895.

## of the ABERDEEN SHOW, 1894.

### DISCHARGE.

| | | | |
|---|---|---|---|
| 1. SHOWYARD EXPENDITURE— | | | |
| Fitting up Showyard | | | £2,438 7 9 |
| Rosettes | | | 32 13 7 |
| Turnstiles | | | 31 4 0 |
| Poultry Pens | | | 5 6 6 |
| Miscellaneous | | | 39 13 5 |
| | | | £2,547 5 3 |
| New Front to Committee-Room | | | 157 11 0 |
| | | | £2,704 16 3 |
| 2. FORAGE FOR STOCK | | | 251 15 6 |
| 3. POLICE | | | 113 8 10 |
| 4. TRAVELLING EXPENSES of Judges, Stewards, &c. | | | 150 7 7 |
| 5. HOTEL AND LUNCHEONS— | | | |
| Hotel Bill for 32 Directors, 7 Stewards, 26 Judges, Auditor, Veterinary Inspector, Engineer, Secretary, &c. | | £293 13 2 | |
| Luncheons in Showyard for Judges, Directors, Attending Members, and Members of Committee, and Breakfasts for Stewards, Assistants, &c. | | 81 17 6 | |
| | | | 375 10 8 |
| 6. MUSIC in Showyard | | | 46 7 6 |
| 7. PRINTING | | | 259 7 7 |
| 8. ADVERTISING and Bill-posting | | | 129 13 6 |
| 9. VETERINARY INSPECTION | | | 5 0 0 |
| 10. WORKING DAIRY | | | 89 13 6 |
| 11. HIGHLAND INDUSTRIES | | | 18 19 0 |
| 12. HORSE-SHOEING | | | 36 1 0 |
| 13. PRACTICAL ENGINEER | | | 37 5 6 |
| 14. OUTLAYS in connection with visit of the Duke of York | | | 242 18 3 |
| 15. EXHIBITION OF BINDERS and TRIAL OF MANURE DISTRIBUTORS | | | 55 6 5 |
| 16. EXTRA CLERKS, Yardsmen, Attendants at Turnstiles, Gates, &c. | | | 152 19 6 |
| 17. DONATIONS to Royal Infirmary and Sick Children's Hospital, being amount drawn at Royal Pavilion | | | 14 19 0 |
| 18. POSTAGES | | | 48 10 0 |
| 19. MISCELLANEOUS PAYMENTS | | | 12 1 4 |
| AMOUNT OF GENERAL EXPENSES | | | £4,745 0 11 |
| 20. PREMIUMS drawn at 30th November 1894 | | | 1,997 10 6 |
| | | | £6,742 11 5 |
| BALANCE OF RECEIPTS | | | 1,802 4 1 |
| | | | £8,544 15 6 |

W. S. WALKER, *Treasurer.*
JAS. H. GIBSON-CRAIG, *Member of Finance Committee.*
WM. HOME COOK, C.A., *Auditor.*

## ABSTRACT of the ACCOUNTS of the ARGYLL NAVAL FUND for 1893-94.

### *CHARGE.*

| | | | |
|---|---|---|---|
| 1. Funds as at 30th November 1893— | | | |
| £3193, 6s. 8d. 3 per cent Debenture Stock of the North British Railway Company, purchased at . . . . . | | | £2,650 0 0 |
| £3,000 Funded Debt of the Clyde Navigation Trustees, purchased at | | | 2,970 0 0 |
| £305 Royal Bank of Scotland Stock, purchased at . . | | | 671 0 0 |
| | | | £6,291 0 0 |
| Balance in Royal Bank on Current Account . . . | | | 369 19 1 |
| | | | £6,660 19 1 |
| 2. Income received— | | | |
| (1) Interest on Investments— | | | |
| On £3,193, 6s. 8d. North British Railway Company 3 per cent Debenture Stock, £95, 16s., tax £3, 0s. 9d. . . . . | £92 15 3 | | |
| On £3,000 Funded Debt of the Clyde Navigation Trustees at 4 per cent, £120, tax £3, 15s. . . . . . . | 116 5 0 | | |
| On £305 Royal Bank Stock . . . | 27 9 0 | | |
| | £236 9 3 | | |
| (2) Income Tax repaid by Inland Revenue for three years to December 1893 . . . . | 20 8 0 | | |
| | | | £256 17 3 |
| Sum of Charge . . | | | £6,917 16 4 |

### *DISCHARGE.*

| | | | | |
|---|---|---|---|---|
| 1. Allowance to the six following Recipients— | | | | |
| Colin Kenneth Maclean, first year . . . . . . | | | | £40 0 0 |
| Leslie Menzies, first year . . . . . . . | | | | 40 0 0 |
| John Allan Gregory, second year . . . . . . | | | | 40 0 0 |
| C. D. L. MacEwan, fourth year . . . . . . | | | | 40 0 0 |
| C. W. Campbell Strickland, sixth year . . . . . | | | | 40 0 0 |
| Colin Mackenzie, sixth year . . . . . . | | | | 40 0 0 |
| | | | | £240 0 0 |
| 2. Funds as at 30th November 1894— | | | | |
| £3,193, 6s. 8d. 3 per cent Debenture Stock of the North British Railway Company, purchased at | | £2,650 0 0 | | |
| £3,000 Funded Debt of the Clyde Navigation Trustees, purchased at . . . . . | | 2,970 0 0 | | |
| £305 Royal Bank of Scotland Stock, purchased at | | 671 0 0 | | |
| | | £6,291 0 0 | | |
| Balance in Royal Bank of Scotland— | | | | |
| On Deposit Receipt, dated 8th March 1894 . . . | £200 0 0 | | | |
| On Current Account . . | 186 16 4 | | | |
| | | 386 16 4 | | |
| | | | | 6,677 16 4 |
| Sum of Discharge . . | | | | £6,917 16 4 |

W. S. WALKER, *Treasurer.*
JAS. H. GIBSON-CRAIG, *Member of Finance Committee.*
WM. HOME COOK, C.A., *Auditor.*

Edinburgh, 9*th January* 1895.

# PROCEEDINGS AT BOARD MEETINGS.

## MEETING OF DIRECTORS, 7TH FEBRUARY 1894.

*Present.—Vice-Presidents*—Sir Allan R. Mackenzie of Glenmuick, Bart.; Mr Gilmour of Montrave. *Ordinary Directors*—Mr Glendinning, Hatton Mains; Mr A. M. Gordon of Newton; Mr Ferguson, Pictstonhill; Mr Elliot, Hollybush; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Pott of Dod; Mr Speir, Newton Farm; Mr Dun, Easter Kincaple; Mr Davidson, Saughton Mains; Mr Lumsden of Balmedie; Mr Macpherson Grant of Drumduan; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Mr Malcolm, Dunmore Home Farm; Captain Robert Dundas, yr. of Arniston; Mr Cowe, Balhousie; Mr Lockhart, Mains of Airies; Mr Cameron, Balnakyle. *Extraordinary Directors*—Mr Gordon Duff of Drummuir; Mr Buttar, Corston; Mr Walker, Portlethen; Mr Mackenzie, Dalmore; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Howatson of Dornel; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Wilson, yr. of Carbeth; Mr Allan, North Kirkland; Mr Cran, Kirkton. *Honorary Secretary*—Sir G. Graham Montgomery of Stanhope, Bart. *Engineer*—Mr J. D. Park. *Veterinary Surgeon*—Professor Williams. *Chemist*—Dr A. P. Aitken. Sir Allan R. Mackenzie, and afterwards Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The SECRETARY reported apologies for the absence of the Earl of Strathmore; Mr Aitken, Norwood; Mr Morton Campbell, yr. of Stracathro; Mr Duff, Hatton Castle; Mr Duthie, Tarves; Mr Forbes of Culloden; Mr M'Gibbon, Ardnacraig; Mr Sinclair Scott, Burnside; Colonel Stirling of Kippendavie.

### THE LATE MR DUNCAN AND THE LATE MR GOURLAY STEELL.

The Directors decided to record in their minutes an expression of their regret at the death of Mr Thomas Duncan, late Chief Clerk of the Society, and of Mr Gourlay Steell, R.S.A., Animal Portrait Painter to the Society.

### CHAIRMANSHIP OF THE BOARD OF DIRECTORS.

In accordance with the new by-law, Sir James Gibson-Craig, Bart., was appointed the Chairman of the Board of Directors for the ensuing year.

### ABERDEEN SHOW.

*Prize List.*—The Prize List of the Aberdeen Show was finally adjusted and will be issued next week. An offer by Sir T. D. Gibson Carmichael of a special prize of £10 for the best pen of blackfaced ewes in the showyard was accepted with thanks. Prizes were arranged for horse-shoeing and for butter-making competitions.

*Forage.*—A Committee was appointed to invite offers for the supply of forage for the Aberdeen Show.

*Hotel Accommodation, &c.*—It was also remitted to Committees to arrange for hotel accommodation and for catering in the showyard.

### COMMITTEES FOR 1894.

The list of the Standing Committees for the year was revised.

### FRAUDULENT SALE OF FOREIGN MEAT.

Mr SCOTT DUDGEON moved the following motion: "That in accordance with the resolution adopted at the Anniversary Meeting, the Board (1) urge upon the Board of Agriculture the extreme importance of taking immediate steps to prevent the sale of foreign meat in name and form of British meat, and, if necessary, calling upon the Government to introduce such a measure as would enable the authorities to effectually put an end to this fraudulent practice, and (2) address a communication to the Royal Agricultural Society of England, the Royal Dublin Society, and the leading local Agricultural Societies in Scotland, directing their attention to the injustice which British live-stock owners suffer from this fraudulent practice in the sale of foreign meat, and urging them to press the matter upon the immediate attention of Parliament.

Mr MARR seconded the motion, which was unanimously adopted, and a small Committee was nominated to carry it into effect.

### ELECTION OF EXTRAORDINARY DIRECTORS.

Mr JOHN SPEIR moved: "That a Committee be appointed to reconsider by-law No. 5 regarding the reappointment of Extraordinary Directors, and to make such suggestions as they may think fit." Mr COWE seconded.

Mr FERGUSON moved the previous question, which was seconded by Mr Gordon. On a division, the previous question was carried by 21 votes to 5.

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## MEETING OF DIRECTORS, 7TH MARCH 1894.

*Present.*—*Vice-President*—Sir Allan R. Mackenzie of Glenmuick, Bart. *Ordinary Directors*—Mr Glendinning, Hatton Mains; Mr A. M. Gordon of Newton; Mr W. S. Ferguson, Pictstonhill; Mr Elliot, Hollybush; Mr Sinclair Scott, Burnside; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Speir, Newton Farm; Mr Davidson, Saughton Mains; Mr Lumsden of Balmedie; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Mr Malcolm, Dunmore Home Farm; Captain Robert Dundas, yr. of Arniston; Mr Cowe, Balhousie; the Hon. the Master of Polwarth, Humbie House. *Extraordinary Directors*—Mr Buttar, Corston; Mr Howatson of Dornel; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Wilson, yr. of Carbeth; Mr Cran, Kirkton. *Chemist*—Dr A. P. Aitken. *Auditor*—Mr Home Cook, C.A. *Engineer*—Mr J. D. Park. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The SECRETARY reported apologies for the absence of the Earl of Strathmore, the Lord Provost of Aberdeen, Sir G. Graham Montgomery of Stanhope, Bart.; Mr Aitken, Norwood; Mr Allan, North Kirkland; Mr Dun, Easter Kincaple; Mr Duthie, Tarves; Mr Gilmour of Montrave; Mr Macpherson Grant of Drumduan; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Middleton, Clay of Allan; Mr Pott of Dod; Colonel Stirling of Kippendavie; Mr Walker, Portlethen.

### ABERDEEN SHOW.

*Prizes by the Duke of York.*—The SECRETARY stated that H.R.H. the Duke of York had offered a series of twenty champion bronze medals to be offered for the best animal in the various sections of stock. The Secretary also stated that he had been instructed to have a medal of a special design prepared in Edinburgh. It was agreed to accept his Royal Highness's offer with the best thanks of the Board, and that the medals shall be offered for the best animal or pen in the following sections: Shorthorn, Aberdeen-Angus, Galloway, Highland, Ayrshire, fat cattle, Clydesdale stallions, Clydesdale mares and fillies, draught geldings, hunters, roadsters, hackneys, ponies, Shetland ponies, blackfaced sheep, Cheviots, Border Leicesters, Shropshires, fat sheep, and swine.

*Special Prizes.*—It was agreed to accept the following special prizes: (1) by Mrs Morison Duncan of Naughton, £10 for the best Aberdeen-Angus heifer; (2) by Sir

Allan Mackenzie and Mr Gordon of Newton, a champion prize of £10 for jumping; (3) by the Scottish breeders of Shropshire sheep, £10 for pens of cross-bred lambs got by Shropshire tups; and (4) by Mr Howatson of Glenbuck, £2 for the best pen of blackfaced wethers, age and quality considered.

*Forage.*—On the recommendation of the Committee, arrangements were made for the forage supply at the Aberdeen Show.

*New Front for Committee-Room.*—It was decided to accept a tender from the Society's contractor for the erection of a permanent ornamental front for the Committee-room in the showyard.

*Trials of Implements.*—It was reported that the Machinery Committee had met that day, and arranged that the competitive trial of manure-distributors and the exhibition of binders at work shall take place in the Aberdeen district at the same time and place next harvest. Entries to be accepted up to the 7th of July.

### Highland Cattle.

A letter was submitted from the Highland Cattle Society, urging that the classes for Highland cattle in the showyard should be confined to animals entered in or eligible for entry in the Highland Herd-Book. After some discussion, it was agreed to delay further consideration of the question till the November meeting.

### Chemical and Botanical.

The Secretary reported that the Chemical Committee had met that morning, and discussed the plan of investigations to be conducted during the year by the Society's chemist and botanist as to pasture grasses and finger-and-toe in turnips. The Committee had also had under its consideration the question of manures and feeding-stuffs found deficient by local analytical associations, the subject being continued for further consideration. The unit schedule of manures for 1894 was laid on the table and approved of. The conditions as to the experiment in the top-dressing of lea oats were also submitted and approved of.

### Showyard Erections.

It was remitted to a Committee to take tenders for the erections in the Society's showyard, the present contract expiring with the Aberdeen Show.

### Animal Painter.

It was decided that the vacancy in the office of animal portrait-painter to the Society, caused by the death of Mr Gourlay Steell, R.S.A., be not filled up in the meantime.

### Dairy Diplomas.

The following letter from the Board of Agriculture was read:—

"*15th February.*

"Sir,—With reference to the copy of a resolution of the Highland and Agricultural Society transmitted in your letter of the 30th ult., I am directed by the Board of Agriculture to state that they are advised that the steps contemplated in 1891 to provide a scheme of dairy examinations could not be given effect to without legislation, and it would not be possible for the Board to propose such legislation until the position of Her Majesty's Government in regard to the organisation and supervision of technical education generally has been further considered and defined.—I am, &c.,

"T. H. Eliott."

Mr Gillespie intimated that he would bring the subject again before the Board on an early date.

### Increase of Crows.

A letter was read from Mr W. N. Scott as to the increase of crows and the great damage they are doing to farm crops.

Various members spoke of the great increase in the number of crows and the damage done to farm crops, and the hope was strongly expressed by the Board that proprietors and tenants would combine and put forth efforts at the nesting season to lessen the plague.

### Selling by Live-Weight.

A resolution was submitted from the Windygates Agricultural Society in favour of the introduction of selling cattle by live-weight. The Board approved of the resolution.

### Abortion in Cattle.

The Secretary stated that he had received from the Secretary of the Royal Agricultural Society of England some copies of schedules issued by that Society as to an inquiry regarding abortion in cows, and intimated that he would be glad to give a copy of the circular to stock-owners who might be able to give information on the subject.

### Rothamsted Reports.

The Secretary stated that he had received from the Board of Agriculture, to be placed in the library of the Society, a full set of the reports of the Rothamsted experiments. The Secretary was asked to convey the thanks of the Directors to the Board of Agriculture, and it was decided that the reports shall lie in the Society's offices for reference, but shall not be removed therefrom.

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## MEETING OF DIRECTORS, 4th APRIL 1894.

*Present.—Vice-President*—Mr Gilmour of Montrave. *Ordinary Directors*—Mr A. M. Gordon of Newton; Mr Aitken, Norwood; Mr Ferguson, Pictstonhill; Mr Elliot, Hollybush; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Speir, Newton; Mr Dun, Easter Kincaple; Mr Lumsden of Balmedie; Mr Macpherson Grant of Drumduan; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Mr Malcolm, Dunmore Home Farm; Captain Robert Dundas, yr. of Arniston; Mr Cowe, Balhousie; Mr Lockhart, Mains of Airies; the Hon. the Master of Polwarth, Humbie House. *Extraordinary Directors*—Mr Duff, Hatton Castle; Mr Fletcher of Letham Grange; Mr Buttar, Corston; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Howatson of Dornel; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Wilson, yr. of Carbeth. *Hon. Secretary*—Sir G. Graham Montgomery of Stanhope, Bart. *Chemist*—Dr A. P. Aitken. *Botanist*—Mr A. N. M'Alpine. *Engineer*—Mr J. D. Park. *Veterinary Surgeon*—Professor Williams. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The Secretary reported apologies for the absence of the Earl of Strathmore; Sir Allan Mackenzie of Glenmuick, Bart.; Mr Allan, North Kirkland; Mr Cameron, Balnakyle; Mr Home Cook, C.A.; Mr Cran, Kirkton; Mr Davidson, Saughton Mains; Mr Duthie, Tarves; Mr Forbes of Culloden; Mr Hay, Little Ythsie; Mr M'Gibbon, Ardnacraig; Mr Pott of Dod; Mr Sinclair Scott, Burnside; Colonel Stirling of Kippendavie.

### Aberdeen Show.

It was remitted to the Directors in the district to nominate the usual local Committee of Superintendence.

The following gentlemen were reappointed as Stewards: *Cattle*—The Rev. John Gillespie. *Horses*—Sir Allan Mackenzie. *Sheep, &c.*—Mr Elliot, Hollybush. *Forage*—Mr Buttar. *Parade Stand*—Mr Macduff. *Implements*—Mr Middleton and Mr Glendinning.

It was agreed that the headquarters of the Society during the Show week be at the Imperial Hotel, Aberdeen.

It was remitted to the Dairy Committee to carry out the arrangements for the working dairy in the showyard.

### Dumfries Show, 1895.

It was remitted to the Directors in the district to nominate a Committee for raising subscriptions towards the expenses of the Show at Dumfries in 1895.

### Show for 1896.

It was agreed that, subject to satisfactory local arrangements, pecuniary and otherwise, the Show be held at Perth in 1896.

### Appointment of Judges.

On the motion of Mr W. S. Ferguson, seconded by Mr Buttar, it was agreed to appoint the judges at next meeting of the Board, and to publish their names at least a week before the closing of the entries.

### Fraudulent Sale of Foreign Meat.

Mr Gillespie directed attention to the replies given in the House of Commons on Tuesday night by Mr Gardner to the effect that he considered the present law sufficient to check the fraudulent sale of foreign meat, and that the initiative in prosecuting breaches of the law should be undertaken by agriculturists themselves or by organisations on their behalf. The Board were unanimous in holding that the present law is not sufficient, and it was remitted to the Committee on the subject to put themselves into communication with the Royal Agricultural Society of England and Agricultural Societies in Scotland with a view of approaching the Board of Agriculture by deputation or otherwise.

### Damage to Crops by Birds.

Mr Gilmour gave an interim report as to the investigations being conducted by Professor M'Alpine as to the damage to farm crops by rooks, pigeons, and starlings. The Board considered that the report was interesting in itself, and gave promise that the results would be of great practical value to agriculturists.

### Grant to Irish Veterinary College.

It was remitted to the Veterinary Committee to make a representation to the Government as to the disadvantage in which the existing Veterinary Colleges would be placed by the establishment of a Veterinary College in Ireland by means of public money.

### Awards in Agricultural Class, Edinburgh University.

The prizes of £10, given in books by the Society to the Agricultural Class in the University of Edinburgh, have this year been awarded to David F. Chalmers, Camregan, Girvan, and Herbert S. Daine, Woolfall Hall Farm, Huyton, Liverpool, who were adjudged equal.

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## MEETING OF DIRECTORS, 2D MAY 1894.

*Present.*—*Vice-President*—Mr Gilmour of Montrave. *Ordinary Directors*—Mr Glendinning, Hatton Mains; Mr Gordon of Newton; Mr Ferguson, Pictstonhill; Mr Elliot, Hollybush; Mr Sinclair Scott, Burnside; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Pott of Dod; Mr Dun, Easter Kincaple; Mr Davidson, Saughton Mains; Mr Macpherson Grant of Drumduan; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Captain Clayhills Henderson of Invergowrie, R.N.; Mr Malcolm, Dunmore Home Farm; Mr Cowe, Balhousie; Mr Lockhart, Mains of Airies; Mr Cameron, Balnakyle; the Hon. the Master of Polwarth, Humbie House. *Extraordinary Directors*—Mr G. A. Duff, Hatton Castle; Mr Duff of Drummuir; Mr Buttar, Corston; Mr Duthie, Tarves; Mr Hay, Little Ythsie; Mr Macduff of Bonhard; Mr Howatson of Dornel; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Wilson, yr. of Carbeth; Mr Allan, North Kirkland; Mr Cran, Kirkton. *Hon. Secretary*—Sir G. Graham Montgomery of Stanhope, Bart. *Chemist*—Dr A. P. Aitken. *Engineer*—Mr James D. Park. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The Secretary reported apologies for the absence of the Earl of Strathmore; Sir Allan Mackenzie of Glenmuick, Bart.; Mr Aitken, Norwood; Mr Mackenzie, Dalmore; Mr Martin of Auchendennan; Mr Speir, Newton Farm; Colonel Stirling of Kippendavie; Mr Walker, Portlethen.

### General Meeting.

The date of the general meeting was fixed for Wednesday, June 20.

### Aberdeen Show.

*Visit of Duke of York.*—The Secretary stated that he had received a letter from Sir Francis de Winton, intimating that H.R.H. the Duke of York would attend the

Aberdeen Show on Wednesday and Thursday, the second and third days of the Show.

*Judges.*—The judges for the various classes of stock were nominated, and the Secretary was instructed to have the list published as soon as it is completed.

*Local Committee.*—The Secretary stated that the Directors of the Aberdeen Show district met in Aberdeen on 27th ult. and nominated a local Committee of Management. The list as recommended was approved.

*Swine Order.*—It was intimated that entries of swine could not be accepted from districts which have been declared to be infected areas under the Swine Fever Orders issued by the Board of Agriculture.

### Injury to Crops by Rooks, Pigeons, etc.

Mr Gilmour of Montrave reported briefly results of investigations conducted for him by Professor M'Alpine as to the injury to crops by rooks, starlings, pigeons, &c.

### Fraudulent Sale of Foreign Meat.

It was reported that a large number of societies had approved of the suggestion that a deputation should wait on the Presidents of the Board of Agriculture and Board of Trade, to urge upon them the desirability of more stringent measures being taken to put a stop to the fraudulent sale of foreign meat. The Secretary intimated that he had just received information to the effect that the Council of the Royal Agricultural Society of England had decided to take no action in the matter until the President of the Board of Agriculture had brought in the bill, in which he promised to transfer to the Board of Agriculture the powers now possessed by the Board of Trade.

After some discussion, it was agreed to delay further action until the meeting of the Board on the first Wednesday of June.

### The Dairy.

On the recommendation of the Dairy Committee, the Secretary received instructions as to the arrangements for the working-dairy and butter-making competitions in the Aberdeen Show. It was also agreed that of the Society's grant for dairy education the sum of £60 should be paid to the Kilmarnock Dairy School, and £20 to the Angus and Mearns Dairy School, with an intimation to the latter that the Society would not in after years be in a position to make a grant towards county schools.

### The Irish Veterinary College.

On the recommendation of the Veterinary Committee, it was unanimously agreed to send a resolution to the Government anent the proposed grant of £15,000 for the establishment of an Irish Veterinary College, urging that in the event of that proposal being carried out the existing Veterinary Colleges in England and Scotland should receive Government support.

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## MEETING OF DIRECTORS, 6th JUNE 1894.

*Present.—Ordinary Directors*—Mr Stirling of Kippendavie; Mr Glendinning, Hatton Mains; Mr Aitken, Norwood; Mr Ferguson, Pictstonhill; Mr Elliot, Hollybush; Sir Robert Menzies of Menzies, Bart.; Sir James H. Gibson-Craig of Riccarton, Bart.; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Dun, Easter Kincaple; Mr Macpherson Grant of Drumduan; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Captain Clayhills Henderson of Invergowrie, R.N.; Mr Malcolm, Dunmore; Mr Cowe, Balhousie. *Extraordinary Directors*—Mr Duff of Drummuir; Mr Buttar, Corston; Mr Mackenzie, Dalmore; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Forbes of Culloden; Mr Wilson, yr. of Carbeth; Mr Cran, Kirkton. *Chemist*—Dr A. P. Aitken. *Auditor*—Mr Wm. Home Cook, C.A. *Engineer*—Mr J. D. Park, C.E. *Veterinary Surgeon*—Professor Williams. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The Secretary reported apologies for the absence of the Marquis of Huntly; the Earl of Strathmore; the Hon. the Master of Polwarth, Humbie House; Sir J. Graham Montgomery of Stanhope, Bart.; Mr Cameron, Balnakyle; Mr Davidson, Saughton

Mains; Mr Gilmour of Montrave; Mr Gordon of Newton; Mr Howatson of Glenbuck; Mr M'Gibbon, Ardnacraig; Mr Paterson, Hill of Drip; Mr Sinclair Scott, Burnside; Mr Walker, Portlethen.

### Aberdeen Show.

It was decided to have the usual dinner for the Directors, judges, and friends on the evening of Tuesday, the first day of the Show.

It was remitted to the Directors of the district and the Local Committee to arrange for jumping competitions on the evenings of Wednesday and Thursday.

It was intimated that final arrangements had now been made whereby H.R.H. the Duke of York would visit the Show on Tuesday and Wednesday. His Royal Highness will be present at the forenoon and afternoon parades on both days, and preside at the general meeting in the showyard on Wednesday.

Directors were appointed to attend on the various classes of stock during the judging.

It was agreed to have the usual service in the showyard for the attendants on the Sunday preceding the Show.

### Appointment of Judges.

On the motion of Mr John M. Martin, seconded by the Rev. John Gillespie, it was unanimously resolved that the judges for the Shows of the Society be appointed at the April meeting hereafter.

### Fraudulent Sale of Foreign Meat.

The Secretary stated that the President of the Board of Agriculture, along with the President of the Board of Trade, would on the 29th inst. receive a deputation from Agricultural Societies with reference to the suppression of fraudulent practices in the sale of foreign meat. It was remitted to the Society's Committee in charge of the matter to make final arrangements for the deputation.

### Importation of Canadian Cattle.

The following resolution was moved by Mr Martin, and seconded by Mr Forbes of Culloden: "That the Directors of the Highland and Agricultural Society view with surprise the statement made in the House of Commons by Sir John Leng on the 29th May, that the majority of Scotch agriculturists are in favour of the immediate removal of the restrictions on the importation of Canadian cattle into this country. The Directors cordially support the past policy of the Minister of Agriculture on this question, and earnestly trust that it may be continued until he and his professional advisers are assured that all danger of the introduction of pleuro-pneumonia with Canadian cattle has been removed."

The previous question having been moved by Captain Clayhills Henderson, the Board divided, when Mr Martin's resolution was adopted by 14 to 7.

### Dumfries Show, 1895.

The Rev. Mr Gillespie reported that preliminary arrangements were being made for the Show of the Society to be held at Dumfries next year.

### General Meeting.

The programme of business for the general meeting on the 20th inst. was submitted, and the Directors were reminded that nominations for the election of new members would be received up to that morning.

## MEETING OF DIRECTORS, 20TH JUNE 1894.

*Present.—Ordinary Directors*—Mr Glendinning, Hatton Mains; Mr Gordon of Newton; Mr Elliot, Hollybush; Sir Robert Menzies of that Ilk, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Rev. John Gillespie, Mouswald; Mr Davidson, Saughton Mains; Mr Scott Dudgeon, Longnewton; Captain Clayhills Henderson of Invergowrie, R.N.; Mr Malcolm, Dunmore Home Farm; Mr Cowe, Balhousie; Hon. the Master of Polwarth. *Extraordinary Directors*—Mr Morton Campbell of Stracathro; Mr Buttar, Corston; Mr Macduff of Bonhard; Mr Howatson of Glenbuck; Mr Shirra Gibb, Boon. *Chemist*—Dr A. P. Aitken. *Engineer*—Mr James J. D. Park. *Veterinary Surgeon*—Principal Williams. Sir James H. Gibson-Craig in the chair.

The business referred to the Aberdeen Show and arranging the programme for the general meeting of this date.

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## MEETING OF DIRECTORS, 7TH NOVEMBER 1894.

*Present.—Ordinary Directors*—Mr G. R. Glendinning, Hatton Mains; Mr W. S. Ferguson, Pictstonhill; Mr D. M'Gibbon, Ardnacraig; Mr Walter Elliot, Hollybush; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Speir, Newton Farm; Mr George Dun, Easter Kincaple; Mr C. Macpherson Grant of Drumduan; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Mr W. T. Malcolm, Dunmore; Mr George Cowe, Balhousie; Mr Lockhart, Mains of Airies; Mr Cameron, Balnakyle. *Extraordinary Directors*—Mr Buttar, Corston; Mr Alexander Macduff of Bonhard; Mr Martin of Auchendennan; Mr Howatson of Dornel; Mr Ballingall, Dunbog; Mr David Wilson, yr. of Carbeth; Mr Andrew Allan, North Kirkland; Mr Cran, Kirkton. *Auditor*—Mr Wm. Home Cook, C.A. *Engineer*—Mr James D. Park. *Veterinary Surgeon*—Professor Williams. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The SECRETARY reported apologies for the absence of the Earl of Strathmore; the Hon. the Master of Polwarth, Humbie House; Lord Provost Stewart, Aberdeen; Sir Robert Menzies of Menzies, Bart.; Mr Aitken, Norwood; Mr Duthie, Tarves; Mr Fletcher of Letham Grange; Mr Forbes of Culloden; Mr Gilmour of Montrave; Mr Gordon of Newton; Mr Hay, Little Ythsie; Captain Clayhills Henderson of Invergowrie, R.N.; Mr Lumsden of Balmedie; Mr Paterson, Hill of Drip; Mr Sinclair Scott, Burnside; Colonel Stirling of Kippendavie; Mr Walker, Portlethen.

### ABERDEEN SHOW.

A preliminary statement of the accounts of the Aberdeen Show, 1894, was submitted, showing a probable surplus of over £1600.

A vote of thanks was passed by acclamation to Lord Provost Stewart, Aberdeen, for his great services in connection with the Aberdeen Show, and for his handsome hospitality to the Directors and officials of the Society.

The list of awards at the Aberdeen Show was submitted, and instructions given for payment of the prizes.

A list of members whose tickets had been transferred at the Aberdeen Show was submitted, and each case considered individually.

### DUMFRIES SHOW, 1895.

It was stated by the Rev. JOHN GILLESPIE that the County Councils of Dumfries, Wigtown, and Kirkcudbright had resolved to raise a voluntary assessment in aid of the Show of next year, as was done in former times by the old Commissioners of Supply. He also stated that the Town Council of Dumfries had voted a sum of £75 towards the Show fund, this being £25 more than the vote to former Shows. Mr Gillespie believed that in addition a considerable sum would be raised by general subscriptions, and it was remitted to a Committee to promote this subscription list.

It was remitted to a Committee to consider and report to next meeting of the Board as to the site for the Dumfries Show, and as to the supply of forage.

An offer of two ten-guinea cups for the best male and the best female Galloway at the Dumfries Show was accepted, with thanks.

### Reporting of Board Meetings.

On the motion of Mr W. S. Ferguson, seconded by Mr Howatson, the following resolutions were unanimously adopted: (1) "That reporters be admitted to the ordinary meetings of the Board;" and (2) "That it be remitted to a Committee to consider and report as to what changes, if any, should be made in the methods of conducting the business of the Board in view of the admission of reporters."

### Various.

On the recommendation of the Finance Committee, the salary of Mr Macdiarmid, chief clerk to the Society, was increased by £50.

The Chemical Committee reported that they had formed a draft scheme for the future working of the Chemical Department, and that this scheme would be printed and circulated amongst the Directors for consideration at next meeting of the Board.

It was agreed to urge the Board of Agriculture to take immediate steps for dealing with tuberculosis in cattle.

Reports for the last three months were submitted of the investigations being conducted for Mr Gilmour of Montrave by Professor M'Alpine as to injury to crops by rooks, starlings, pigeons, &c., and instructions were given that these very interesting reports should be sent to the agricultural newspapers for publication.

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## MEETING OF DIRECTORS, 5th DECEMBER 1894.

*Present.—Vice-President*—Mr Gilmour of Montrave. *Ordinary Directors*—Mr Stirling of Kippendavie; Mr Glendinning, Hatton Mains; Mr Aitken, Norwood; Mr W. S. Ferguson, Pictstonhill; Mr Elliot, Hollybush; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Spier, Newton Farm; Mr Dun, Easter Kincaple; Mr James J. Davidson, Saughton Mains; Mr Lumsden of Balmedie; Mr Scott Dudgeon, Longnewton; Mr Cross of Knockdon; Captain Clayhills Henderson of Invergowrie, R.N.; Mr W. T. Malcolm, Dunmore Home Farm; Captain Robert Dundas, yr. of Arniston; Mr Cowe, Balhousie; Mr Lockhart, Mains of Airies; the Hon. the Master of Polwarth. *Extraordinary Directors*—Mr Buttar, Corston; Mr George J. Walker, Portlethen; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Howatson of Dornel; Mr Shirra Gibb, Boon; Mr Ballingall, Dunbog; Mr Wilson, yr. of Carbeth; Mr Cran, Kirkton. *Engineer*—Mr J. D. Park. *Veterinary Surgeon*—Professor Williams. Sir James H. Gibson-Craig of Riccarton, Bart., in the chair.

The Secretary reported apologies for the absence of the Earl of Strathmore; Sir G. Graham Montgomery of Stanhope, Bart.; Sir Allan R. Mackenzie of Glenmuick, Bart.; Mr Allan, North Kirkland; Mr Cameron, Balnakyle; Mr Gordon Duff of Drummuir; Mr Fletcher of Letham Grange; Mr Forbes of Culloden; Mr Gordon of Newton; Mr C. Macpherson Grant of Drumduan; Mr Hay, Little Ythsie; Mr M'Gibbon, Ardnacraig; Mr Mackenzie, Dalmore; Mr Pott of Dod; Mr Sinclair Scott, Burnside; Mr Wm. Home Cook, C.A., auditor.

It was decided to hold the January meeting of the Board on Wednesday the 9th instead of Wednesday the 2d January, and that the annual general meeting of the members of the Society be held on Wednesday, 23d January.

### Dumfries Show.

*Prize List.*—The General Shows Committee reported that they had revised the prize-list, and it was ordered that the prize-list as revised be printed and circulated amongst the Directors for consideration at next Board meeting.

### Site of the Show.

On the recommendation of a Special Committee, it was resolved to hold the Show on a field on Mr Wallace's farm of Terreglestown, close to Dumfries.

### Forage Contract.

A Special Committee appointed for the purpose reported that they had considered the tenders for the supply of forage, and recommended the acceptance of the tender

of Mr Wallace, Terreglestown Farm. The recommendation was unanimously adopted.

### Special Prizes.

The following special prizes were accepted, with thanks to the donors, viz.:—

1. By the Shorthorn Society, £20 for best shorthorn bull.
2. Mr C. Macpherson Grant, £24 for prizes for Aberdeen-Angus cows calved on or after 1st December 1891.
3. Ayrshire Cattle Herd-Book Society, two champion cups, value £50 each, for best registered male and best registered female of the Ayrshire breed.
4. Mr Cross of Knockdon, £20 for prizes for three-year-old Ayrshire cows.
5. Clydesdale Horse Society, Cawdor Challenge Cup for best Clydesdale mare or filly.
6. Mr James Lockhart, champion prize of £10 for best Clydesdale stallion.
7. Mr John Gilmour, £25 for prizes, as at Aberdeen, for yearlings, colts, geldings, or fillies, got by thoroughbred stallions.
8. Mr Charles Howatson, £40 in prizes of £15, £12, £9, and £4, for the best five blackfaced shearling tups, bred and fed by exhibitor (Mr Howatson intimating that he would not be a competitor for these prizes).
9. Sir Thomas Gibson-Carmichael, plate value £10 for best pen of blackfaced ewes or gimmers.
10. Sir James H. Gibson-Craig, £12 for prizes for horse-shoeing as at Aberdeen.

### Appointment of Judges.

It was remitted to a Committee to consider and report as to the regulations for the selection of judges.

### New By-Laws.

On the motion of Sir James Gibson-Craig, Bart., it was unanimously resolved to adopt a new by-law providing that the Society's office-bearers be appointed at the general meeting in June instead of January, and hold office from November to November, instead of from February to February—the new Board to come into office each year at the November meeting, the change to come into operation in 1896. The alteration also providing that the meetings in the Show districts for the nomination of Directors take place in spring instead of autumn.

### Chemical Department.

The Committee appointed specially to consider and report as to the future working of the Chemical Department submitted a report recommending a scheme which would limit the Society's expenditure in the Chemical Department to £450 per annum.

Mr Cowe moved as an amendment a scheme which would limit the expenditure to £300.

On a division the recommendation of the Committee was carried by 24 votes to 4.

### Damage to Crops by Birds.

An interesting report was submitted on the investigations as to the damage to crops by rooks, pigeons, &c., which are being conducted by Mr Gilmour of Montrave.

### Grants to District Shows.

The report of the District Shows Committee as to grants to local Agricultural Societies for 1895 was submitted and approved. It recommended grants for the year amounting to £360, as compared with £250 in 1894.

## MEETING OF DIRECTORS, 9TH JANUARY 1895

*Present.—Vice-President*—Mr Gilmour Montrave. *Ordinary Directors*—Mr Glendinning, Hatton Mains; Mr Ferguson, Pictstonhill; Mr M'Gibbon, Ardnacraig; Mr Elliot, Hollybush; Mr Sinclair Scott, Burnside; Sir Robert Menzies of Menzies, Bart.; Mr Paterson, Hill of Drip; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Rev. John Gillespie, Mouswald; Mr Middleton, Clay of Allan; Mr Pott of Dod; Mr Speir, Newton Farm; Mr Dun, Easter Kincaple; Mr Davidson, Saughton Mains; Mr Cross of Knockdon; Mr Malcolm, Dunmore Home Farm; Captain Dundas, yr. of Arniston; Mr Cowe, Balhousie; Mr Lockhart, Mains of Airies. *Extraordinary Directors*—Mr Buttar, Corston; Mr Duthie, Tarves; Mr Macduff of Bonhard; Mr Martin of Auchendennan; Mr Cran, Kirkton. *Hon. Secretary*—Sir G. Graham Montgomery of Stanhope, Bart. *Chemist*—Dr Andrew P. Aitken. *Auditor*—Mr Wm. Home Cook, C.A. *Engineer*—Mr James D. Park. *Veterinary Surgeon*—Principal Williams. Sir James H. Gibson-Craig in the chair.

The SECRETARY reported apologies for the absence of the Earl of Strathmore; Sir Allan Mackenzie of Glenmuick, Bart.; Mr Aitken, Norwood; Mr Allan, North Kirkland; Mr Scott Dudgeon, Longnewton; Mr Fletcher of Letham Grange; Mr Shirra Gibb, Boon; Mr Gordon of Newton; Mr Howatson of Glenbuck; Mr Lumsden of Balmedie; Colonel Stirling of Kippendavie; Mr Walker, Portlethen; and Mr Wilson, yr. of Carbeth.

### OFFICIALS FOR 1895.

The list of officials for 1895 as now adjusted was formally submitted. In room of Mr Yorstoun of Tinwald, Mr Wellwood Maxwell of Kirkennan, Dalbeattie, was nominated as an Ordinary Director for the Dumfries district.

### ACCOUNTS.

The accounts for the year 1893-94, which will be laid before the general meeting on the 23d inst., were submitted.

### DUMFRIES SHOW.

*Special Prizes.*—A letter was read from the Shorthorn Society intimating that the Society agreed to offer their prize of £20 for shorthorn female instead of shorthorn bull, for which the Tweeddale gold medal is to be offered.

A letter was read from Mr Maxwell of Munches offering £20 as prizes for draught geldings, the offer being accepted with the best thanks.

Mr David Buttar offered, on behalf of Shropshire breeders, the sum of £10 for prizes for cross-bred lambs got by Shropshire tups, this offer also being accepted with the thanks of the Board.

### PRIZE LIST.

The recommendations of the General Shows Committee as to the prize-list were considered, and the Secretary was instructed to have the prize-list printed as it has now been adjusted.

### ADMISSION OF REPORTERS TO BOARD MEETINGS.

The Committee appointed to consider as to any changes in the methods of conducting the business of the Board in view of the admission of reporters submitted their report, which was adopted, and it was decided that the new arrangement of open meetings begin with the meeting on Wednesday, 6th February.

### THE APPOINTMENT OF JUDGES.

The Committee appointed to consider and report as to the regulations for the appointing of judges for the Society's Shows submitted a series of regulations, and it was decided to have these regulations circulated amongst the Directors and brought up for consideration of the meeting of the Board on the forenoon of the general meeting on 23d inst.

### DAMAGES TO CROPS BY BIRDS.

Mr GILMOUR of Montrave submitted a report for the past month on the investigations being conducted for him by Mr M'Alpine as to injury to crops by birds.

### MACHINERY TRIALS.

On the recommendation of the Machinery Committee, it was agreed (1) that an

exhibition of binders at work be held in the Dumfries Show district in the harvest of this year, and (2) that a competitive trial of turnip-lifters be held in the same district next winter, the prizes to be £10 and £5.

### Chemical and Botanical.

On the recommendation of the Chemical and Botanical Committee it was agreed that the Society's Chemist in connection with investigations being conducted by the Carse and Dundee District Farmers' Club make analyses of a number of varieties of Swedes.

It was also agreed to conduct under the joint supervision of the Society's Chemist and Botanist a series of experiments in the Dumfries Show district this year upon the effect of the Bordeaux mixture in the prevention of potato disease.

### Dairy.

On the recommendation of the Dairy Committee it was resolved to ask the general meeting to continue the grant of £60 to the Kilmarnock Dairy School.

### Transactions.

The Publications Committee reported that they were not in a position to recommend the award of any premiums for reports this year, the readers having reported that none of the papers sent in were in their opinion suitable for publication in the Society's Transactions.

### Light Railways.

It was remitted to the General Purposes Committee to watch the movement in promotion of light railways, and to make such recommendations to the Board as they might think desirable.

### Tuberculosis.

A letter was submitted from the Board of Agriculture, stating that the report of the first Commission on Tuberculosis would not be issued until the second Commission had finished its inquiry.

### Forestry Chair Fund.

The following contributions towards the founding of a Forestry Chair in the University of Edinburgh were intimated through Sir Robert Menzies, Bart.: Sir Donald Currie, M.P., £20; Mr Steuart Fotheringham of Murthly, £25; Mr Bunton of Dunalister, £50; and Lady Stewart of Grantully, £10.

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## MEETING OF DIRECTORS, 23d JANUARY 1894.

*Present.—Ordinary Directors*—Mr Ferguson, Pictstonhill; Mr M'Gibbon, Ardnacraig; Mr Elliot, Hollybush; Mr Sinclair Scott, Burnside; Sir Robert Menzies of that Ilk, Bart.; Sir James H. Gibson-Craig of Riccarton, Bart.; Mr Marr, Cairnbrogie; Mr Speir, Newton Farm; Mr Davidson, Saughton Mains: Mr Cross of Knockdon; Mr Malcolm, Dunmore Home Farm; Captain Robert Dundas, yr. of Arniston; Hon. the Master of Polwarth. *Extraordinary Directors*—Mr Fletcher of Letham Grange; Mr Buttar, Corston; Mr Macduff of Bonhard; Mr Wilson, yr. of Carbeth; Mr Allan, North Kirkland. *Hon. Secretary*—Sir G. Graham Montgomery of Stanhope, Bart. *Auditor*—Mr Home Cook, C.A. *Engineer*—Mr J. D. Park. *Veterinary Surgeon*—Principal Williams. Sir James H. Gibson-Craig in the chair.

The Secretary reported apologies for the absence of the Earl of Strathmore; Mr Aitken, Norwood; Mr Cameron, Balnakyle; Mr Cran, Kirkton; Mr Scott Dudgeon, Longnewton; Mr Dunn, Easter Kincaple; Mr Duthie, Tarves; Mr Gilmour of Montrave; Mr Glendinning, Hatton Mains; Mr Gordon of Newton; Mr Howatson of Glenbuck; Mr Lockhart, Mains of Airies; Mr Martin of Auchendennan; Mr Middleton, Clay of Allan; Mr Paterson, Hill of Drip; Mr Walker, Portlethen.

### Dumfries Show, 1895.

*Prizes for Hackneys.*—A letter was read from the Secretary of the Scotch Com-

mittee of the Hackney Horse Society, intimating that that Committee was prepared to contribute a sum of £54, being one-half of the amount of the prizes offered for hackney horses at Dumfries Show. The offer was accepted with thanks.

*Champion Prize for Jumping.*—Mr Ferguson offered on behalf of various contributors a Champion prize of £10 for most points in prizes for jumping by any one exhibitor with one or more horses in the jumping classes. First prize to count 3 points, second 2 points, and third 1 point. In the event of a tie, the money to be divided. The offer was accepted with thanks.

*Conditions attaching to Mr Howatson's Prizes for Pens of five Blackfaced Tups.*—A letter was read from Mr M'Gibbon, suggesting that all tups competing for the prizes offered for pens of five tups should be entered in that class only, and not allowed to be entered or compete in the ordinary class for single shearling tups.

Mr Buttar moved that the groups of five tups be entered in a separate class, and not eligible to compete in any of the other classes. Mr Elliot seconded.

Mr Sinclair Scott moved that tups be allowed to compete both in the ordinary shearling tup class and for Mr Howatson's prizes. Mr Cross seconded.

After some discussion, a show of hands was taken, when Mr Buttar's motion was carried by 11 votes to 4.

*Rules as to Calving and Foaling.*—The Secretary asked whether, in the event of an animal dying before producing a calf or foal as required by Regulations 34, 38, 40, and 41, a prize awarded to that animal should be withheld and paid to the next in order of merit.

The Board unanimously held that failure from death or any other cause to produce a foal or calf as required by these Regulations for the Aberdeen Show was a disqualification; but after discussion it was decided that, to provide for the case of death, Rule 41 in the prize-list be altered by the addition of the following words: "Or in case of death, a veterinary certificate must be produced certifying that at the time of death the animal was so far advanced with calf or foal that, if it had lived, it would have produced a calf or foal as required in Rules 34, 38, 40, and 41."

## Regulations for the Appointment of Judges.

The Regulations for the nomination and selection of judges as recommended by the Special Committee on the subject were considered *seriatim*, and adopted as follows:—

"1. Exhibitors in the various classes of stock shall be invited to nominate judges to act at the Shows of the Society. The final selection of the judge or judges shall rest with the Directors.

"2. Each year every Exhibitor of live stock at any of the three immediately preceding Shows of the Society shall be invited to nominate a list of persons, not exceeding three in number, qualified to act as judges in each class of stock of which he has been an exhibitor. Every third year the Breed Societies shall be invited to favour the Society with a list of qualified judges for the respective classes of stock, the number on the list not to exceed twelve for any breed. The names of the persons thus nominated will be put on a list in alphabetical order, and submitted to the Directors. The last date for receiving nominations will be stated on the circular inviting the lists.

"3. Persons on the said list may be nominated to act as judges on being proposed and seconded by members of the Board present. The list of nominees shall be voted on, and should the number of these receiving not less than five votes of those present, including proposer and seconder, be greater than that required for the class of stock, the final selection (including reserve judges) shall be made by lot. Any Director may propose, second, or support the number of judges required for each class of stock, but not more than that number. Nominations may be made of persons not on the lists received from exhibitors and Breed Societies, provided they are supported by two-thirds of the Directors present.

"4. The Committee recommend that the Board sit in Committee to appoint judges, and that the list be published as soon as completed."

## Agricultural Education.

The alterations on the by-laws for the examinations approved at last meeting of the Board were again submitted and approved.

# PROCEEDINGS AT GENERAL MEETINGS.

## GENERAL MEETING, 20TH JUNE 1894.

Sir JAMES H. GIBSON-CRAIG of Riccarton, Bart., in the chair.

### NEW MEMBERS.

The CHAIRMAN announced that 248 new members fell to be elected that day. In January they had had 119 new members—making a total of 367 for the year. Last year they had 476 members, thus giving a total of 843 in two years.

Sir ROBERT MENZIES, after the members had been balloted for, explained that he had accidentally blackballed the members. He thought the ballot-boxes should be altered in order to prevent a similar mistake occurring again.

The CHAIRMAN then declared the 248 new members to have been unanimously elected.

### ABERDEEN SHOW.

The CHAIRMAN reported that the arrangements for the Aberdeen Show, to be held on the 24th of July and three following days, were as well advanced as they could be at that date. The fact that his Royal Highness the Duke of York would visit the Show had excited the liveliest satisfaction throughout the country; and, as far as one could judge at present, there seemed every prospect of the Show being attended with great success. His Royal Highness would visit the Show on the Wednesday and Thursday, the second and third days, and he was sure they would be pleased to know that his Royal Highness had evinced the heartiest interest in the success of the Show. His Royal Highness intended to present his medals in person at the morning parade on Thursday. The entries of implements had been closed, and it was surprising to find that even the great display of implements at Edinburgh last year would be eclipsed by a yet larger collection at Aberdeen. The entries of live stock closed that forenoon, but as yet nothing more could be said than that a very large and thoroughly representative display of British farm live stock would be found in the showyard on the Aberdeen Links. They would be glad to hear that the very energetic efforts which were made in the Aberdeen Show district to raise subscriptions in support of the Show had met with a gratifying measure of success. The local guarantee fund, under the charge of Mr Gordon of Newton, in aid of the Show had now reached close on £900, and he understood that a good many subscriptions were still expected, so that they had every hope that it would be raised to £1000 before the day of the Show.

### SHOWS FOR 1895 AND 1896.

The CHAIRMAN stated that it was still in the hands of the Committee to get a good site for the 1895 Show to be held at Dumfries. The large district show would not be held there next year. A Local Committee had been formed to collect subscriptions for the guarantee fund, which was all that could be done in the meantime. As regarded the Show of 1896, it was proposed to hold it at Perth if satisfactory arrangements could be made.

### Chemical Department.

Mr Glendinning, Hatton Mains, convener, reported that the Special Committees appointed to consider the future working of the Chemical Department had held several meetings, and had discussed different schemes very fully. It was fully expected that last month a scheme would have been matured, and would have been submitted to this meeting of members; but after lengthy discussion by a large Committee, it was felt that the subject required still further consideration, and accordingly the Committee recommended that the whole matter be remitted back to an enlarged Special Committee. This the Directors agreed to, and it was expected that a satisfactory scheme would be prepared before the end of the year.

The report was adopted.

### Report of Chemist.

Dr Aitken reported as follows:—

The work of the Chemical Department has this year been considerably extended in the direction of local investigations. The farmers in Banffshire, who last year carried out experiments designed to show how the turnip crop may be most economically manured, have, through the Secretaries of the four districts of the county, requested a repetition of the experiment this year, and this is now going on on upwards of thirty farms. In Stirlingshire the experiment on bean-manuring tried last year is also being repeated, and a number of farmers in the Carse of Gowrie and elsewhere have joined in the work. The inquiry into the effects of the application of various manures on pasture and on rotation grass, begun last year in various counties, are still in progress, and it has been taken up for the first time by members of the Lauderdale Agricultural Society this year. There are also two distinct experiments on the manuring of lea oats in progress—one on a number of farms in Aberdeen, and the other on some farms in the Lothians. In view of the importation of new kinds of mineral phosphates, which will shortly be reaching this country in large quantities, their manurial value in the ground state is being tested alongside of other available phosphates, and these experiments differ from those carried out formerly in this respect that all the phosphates are applied in as nearly as possible equal states of fineness. Experiments are also in progress in four counties with the view of finding a cure for finger-and-toe in turnips; and the merits of a disease-resisting variety of turnip-seed is also being tested on farms in various districts widely different in latitude and other circumstances. Two feeding experiments—one with cattle at Mains of Laithers, and another at Ferney Castle with sheep—to compare the feeding value of linseed-cake with that of a mixture of dried grain and decorticated cotton-cake, whose chemical composition approximated to that of linseed-cake, have just been tried. The whole details will not be worked out for some time, but I may say shortly that there seems to be very little difference in the feeding value of the two rations, although the one was only about two-thirds the price of the other. But the conclusions are too important to be accepted on the basis of one series of experiments, and it would be expedient to have them repeated, perhaps on a larger scale, during the coming season. The lots of cattle numbered eight each, and of sheep ten each; but in feeding experiments these must be regarded as the minimum number of animals from which reliable results can be obtained. At the general meeting in January it was resolved to continue giving grants in aid of analyses to local analytical associations until the beginning of March. Four associations have taken advantage of this arrangement, and have sent in reports of twenty-five analyses, consisting chiefly of feeding-stuffs. The samples were all up to their guarantees, and the amount of the grant in respect of them is £11.

Mr Cowe, Balhousie, said that, as regarded experiments being continued, he desired to keep himself perfectly clear on that point. He considered that the sooner these experiments were stopped the better it would be for the interests of the Society.

Dr Aitken explained that the feeding experiments would probably take place in September.

Mr Fyshe, Treaton, Markinch, asked if the turnip-seed experiment did not come under the Botanical Department.

The Chairman stated that it had been remitted to Dr Aitken and Professor M'Alpine to conduct these experiments jointly.

Mr Cowe said that it seemed to him very singular that the two departments were conjoined. Why was there such a difference between the salaries given to each man?

Mr Fyshe said he thought the Botanist should report himself. That would do away with their having two separate departments.

The Chairman said that the departments were separate but worked together.

The report was then adopted.

### Agricultural Education.

The Rev. John Gillespie, Mouswald, reported that the annual examination of candidates for the Society's diploma and certificate was held on the 21st, 22d, and 23d March. The number of candidates who presented themselves was twenty-eight, and the result was that twelve succeeded in passing for the diploma and three obtained the certificate. That was rather an unsatisfactory result as regarded the proportion who passed. It was satisfactory to those who did pass, but not relatively to those who presented themselves. It rather looked as if young gentlemen were coming forward prematurely, when really not prepared to face the examination. As a member of the Council on Education, he would mention that that Council were at present considering the whole arrangements in connection with the examination for the diplomas and certificates. He also announced that the £10 given in prizes to the class of agriculture in the University of Edinburgh had this year been awarded to David F. Chalmers, Camregran, Girvan, and Herbert S. Daine, Woolfall Hall Farm, Huyton, Liverpool, £5 each.

The report was adopted.

### Forestry Examinations.

Sir Robert Menzies reported that the forestry examinations were held on the same days as those for the agricultural diploma, when five candidates came forward. The result was that all the candidates passed for a second-class certificate. He thought the examinations should be made on a different day from that of the agricultural examination, so that students could take both in the same year. As regarded the endowment of the Forestry Chair, he thought that they had succeeded tolerably well. They had received nearly half of the sum required from fifty-one subscribers. They were now about to issue an appeal to the whole of Scotland, asking for additional subscriptions. He had no doubt that when the scheme was brought before the small proprietors they would get the desired sum.

Mr Fyshe congratulated Sir Robert Menzies on his men passing second-class. He was delighted so much progress had been made.

The report was then agreed to.

### Chairman of Board.

The following new by-law was unanimously confirmed: "The Board shall have power to appoint one of its number to act as Chairman of the Board and of the Deputation of Directors at the Annual Show, the said Chairman to retire at the end of the year, but if a member of the Board, to be eligible for re-election."

### New Volume of 'Transactions.'

The Chairman stated that volume vi. of the fifth series of 'Transactions' had been published and laid before them; he hoped it would meet with their approval.

This concluded the business, and a vote of thanks to the chairman terminated the proceedings.

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## GENERAL MEETING IN THE SHOWYARD AT ABERDEEN, 25th JULY 1894.

His Royal Highness the Duke of York, President, in the chair.

A general meeting of the Society was held at half-past twelve in the Pavilion. The expected presence of the Duke of York had the effect of making the attendance very large, and many members, anxious to secure a good place, were seated fully half an hour before the time fixed for the beginning of the proceedings. Many who were unable to get within the building stood outside, and as the hoarding of one of the walls was not more than breast-high, were thus enabled to see, if not to hear, what took place. Every seat was occupied when his Royal Highness entered, accompanied by the members of his suite and by the Marquis of Huntly, the Earl of Strathmore, Sir Allan R. Mackenzie, Mr A. M. Gordon of Newton, Lord Provost Stewart, Mr Fellowes-Gordon of Knockespock, &c. Business was at once commenced, and Mr Macdonald, the Secretary, read the notice calling the meeting.

The Marquis of Huntly, who was received with cheers, then rose and said: "May it please your Royal Highness, my lords and gentlemen, I have had the honour of being asked to move a resolution at this meeting, and I am sure it is one which will

meet with the hearty approval of every person here. It is an address of congratulation to your Royal Highness upon the birth of your son. I can assure your Royal Highness, in the names of every man, woman, and child in this part of her Majesty's loyal dominions, that the event has caused the greatest gladness and joy. Without saying much more, I may allude to one little matter that perhaps has added to our gratification—that amongst the Royal child's names, I believe for the first time, he has received that of Scotland's patron saint, Andrew,—and I trust that as he grows in years he may be protected by the old Scottish motto, 'Nemo me impune lacessit.' In the name of the members here assembled I beg to move—'That the members of the Highland and Agricultural Society of Scotland, in general meeting assembled, desire to offer their heartiest congratulations to their President, his Royal Highness the Duke of York, upon the birth of a son and heir, and request his Royal Highness to convey to her Royal Highness the Duchess of York the cordial congratulations of the Society upon the happy and auspicious event.'" (Hear, hear, and loud cheers, which were renewed as the Marquis put the resolution to the meeting and asked those in favour of it to say "Content.")

The DUKE OF YORK's rising to respond was the signal for a renewed outburst of cheering, the members of the audience rising to their feet and waving their hats. He said: "My lords and gentlemen, I cannot find words to express my thanks for these very kind expressions which have been used by the Marquis of Huntly. I beg to thank you all, gentlemen, from the bottom of my heart for your congratulations on the birth of our son. I know that when I convey the kind words of this resolution to the Duchess of York, she will be as much touched as I am."

The MARQUIS OF HUNTLY suggested that the Society should have the honour of sending a telegram to the Duchess of York intimating the resolution—a proposal to which his Royal Highness bowed his assent.

## VOTES OF THANKS.

*The Lord Provost and Magistrates.*—Mr GORDON of Newton, who was very cordially greeted, said: "I beg to propose a cordial vote of thanks to the Lord Provost and Magistrates of Aberdeen for the hearty co-operation which they have rendered to this great Society on its visit to the town. Having been chairman of the Local Committee during all the preparations for the Show, I can testify—and I do so with great cordiality and thankfulness—to the great consideration and kindness which have been shown to all the officials of the Society by Lord Provost Stewart. The other night, as you are aware, he entertained at his pretty residence at Banchory House no fewer than fifty Directors of the Society, and he treated us in a style which would have been worthy even of his Royal Highness if he had been present. I can assure you that he has distinguished himself beyond all his predecessors in the civic chair for the kindness with which he has welcomed this Society. When I read the resolution, I trust you will give it such a reception as will show to the town of greater Aberdeen from Torry even to Woodside that we are acclaiming the city fathers with an appropriate sense of gratitude. The resolution is—'That the thanks of the Society be given to the Lord Provost, Magistrates, and Town Council of Aberdeen for the use of the Links, for the donation of £100 voted by the corporation in aid of the funds, and for their assistance and co-operation in furthering the success of the Society.'"

LORD PROVOST STEWART, in reply, said: "If any thanks are required on this occasion, I am sure that they are very greatly enhanced by the handsome way in which Mr Gordon has proposed them and the enthusiastic reception which has been given to his words; but still more I think it is a red-letter day for us to have a vote of thanks passed with the grandson of the Queen in the chair. I feel very grateful to you indeed. So far as I am concerned, I have only done what was my duty, and what was expected of a man who takes the civic chair of Aberdeen. But I have to say that my Magistrates and Town Council have supported me most loyally, and whatever we have done—many of us feel we might have dealt with even a more liberal hand—has been done with the cordial goodwill and the best wishes of every one in Aberdeen for the welfare of this Society, and in order that you should be helped to give a good reception to his Royal Highness the Duke of York."

*The Subscribers.*—The Hon. the MASTER OF POLWARTH said: "I have the honour to move that the thanks of the Society be voted to the subscribers to the funds for the Aberdeen Show, and to the donors of special prizes, for the liberal support they have given. We who come from and represent districts of Scotland further south than this do not fail to appreciate the noble way in which the people of this locality have come forward and have maintained their reputation as leaders in Scottish agriculture. They have contributed to the Show nearly £1000 in one way or another. Without these contributions the Show cannot now go on. We are not in the fortunate position of some of the agricultural societies in our Australian colonies, where I am told the

Government contribute a sum equal to that raised in the locality. Had we been in that position we should have been specially well off, but the people of Aberdeen have shown that by private effort a very great deal can be done; and I would venture to move this motion feeling assured that all of us who represent the rest of Scotland will give special thanks to those in this locality who by their efforts have raised a sum which has made it possible to give so large an amount of prizes. I know it has required an enormous amount of effort, and therefore the local conveners and others in this locality deserve the thanks of the Society."

*The Local Committee.*—The Rev. JOHN GILLESPIE moved: "That the thanks of this Society be given to Mr Gordon of Newton, the convener, and the other members of the Local Committee, for the assistance they have rendered in carrying out the arrangements in connection with the Aberdeen Show." "Everybody," he said, "acquainted with the working of such a Society as this is aware that much depends upon the arrangements made by the Local Committee. Nowhere have we been more fortunate in getting everything arranged beforehand to work in clock-like order than in this noble city. Aberdeen county and those adjoining are in many respects the most prominent in Scotland, and they have come up to their reputation in the arrangements of this Show. I believe they have even arranged the weather to perfection, for so far we have been very fortunate in that respect. Not only north, but also in the south, where his reputation has reached, we feel indebted to Mr Gordon of Newton for his great zeal, energy, and tact in managing everything in connection with the Show. I know well how highly he is appreciated in the north, and we who come from other parts of the country envy you the possession of such a man."

Mr GORDON, who on rising to reply was loudly cheered, said: "I return you my most hearty thanks for the cordial reception you have given the motion proposed in such eloquent and flattering terms by my reverend friend Mr Gillespie. I have only to say that any little thing we have been able to do—myself or those who constitute the very able Local Committee which supported me—has been done with the very best will."

*The Railway Companies.*—Mr DUFF of Hatton moved the next resolution, which was: "That the thanks of the Society be given to the railway companies for the facilities they have provided for exhibits and to the public in connection with the Show."

A motion in favour of the meetings of Directors being open to the press having been postponed, on the suggestion of Mr J. P. Glendinning, Midcalder, who had given notice of it,

Sir JAMES H. GIBSON-CRAIG, Bart. of Riccarton, said: "I have the honour to move that the cordial thanks of the Society be given to his Royal Highness the Duke of York for graciously visiting the Show, for presiding at this meeting, and for the series of medals which he has presented. I am sure it will require no words from me to carry this motion. I am glad I have little to say, for any words I could use would be inadequate. I will only remind you of the satisfaction and pride we experienced when his Royal Highness consented to honour us by becoming our President. That satisfaction was enhanced when he graciously accepted office for a second year, and it has been accentuated now by his presence among us to-day. I cannot remember when our Show was honoured before by the presence of Royalty. I know I am expressing the wishes not only of all here, but of the members of our Society all over Scotland, when I hope that his Royal Highness will take away with him nothing but pleasant recollections of his first visit to a Highland and Agricultural Society's showyard; and I am also quite certain that I am speaking for you all when I most respectfully express the hope that this may not be by any means the last time that he will honour us in this way. It is not only by acting as President and by coming to the Show that he has shown his active and hearty sympathy with Scottish agriculture. By his princely gift of the three champion cups last year, and of the champion medals this year, he has conduced largely to the success of the Shows at Edinburgh and Aberdeen—two which, I think, will compare favourably with any that have ever been held under the auspices of this Society. I think it is a happy augury for Scottish agriculture that the two years he has been President of the Scottish National Society have been signalised by the two most auspicious events of his Royal Highness's life. The first year of his presidency was marked by his marriage, which sent a throb of joy and satisfaction through the heart of the whole Scottish nation. His second year of office has been marked by the birth of a son and heir. May that son and heir grow up to be a joy and a blessing to his Royal parents, and in due course may he take the same hearty, active interest in our national industry that his Royal predecessors have always taken and are taking at this moment. Long may he live to be a blessing and a bulwark of a loyal and devoted people, over whom, in the due fulness of time, long may he reign."

H.R.H. the DUKE OF YORK, on rising to reply, was received with enthusiastic cheers,

those present again rising *en masse*. He said: "I beg to thank Sir James Craig most warmly for the very kind expressions he has used in proposing this vote of thanks, and I thank you all most heartily for the way in which you have received what he has said. I feel it a great honour to have been elected President of this Society for two consecutive years, and I only regret that I was unable to be present at Edinburgh last year. It has given me great pleasure to come here to-day and visit the Show, more especially as it is held this year in the capital of the county in which I have spent so many happy days of my life. As the time at our disposal is so short, I will only say that I wish the Highland and Agricultural Society every possible success and prosperity."

This concluded the meeting.

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## ANNIVERSARY GENERAL MEETING, 23D JANUARY 1895.

Sir JAMES H. GIBSON-CRAIG, Bart., and afterwards the DUKE OF BUCCLEUCH, in the chair.

### NEW MEMBERS.

Eighty-four new members were balloted for and unanimously elected.

The SECRETARY intimated that the Directors recommended the following noblemen and gentlemen for election to fill the vacancies in the list of office-bearers: *President*—The Duke of Buccleuch and Queensberry, K.T. *Vice-Presidents*—The Earl of Stair, K.T.; Sir Robert Jardine of Castlemilk, Bart.; Sir Mark J. Stewart of Southwick, Bart., M.P.; and Wellwood H. Maxwell of Munches. *Ordinary Directors*—David M'Gibbon, Ardnacraig; Andrew Hutcheson, Beechwood; John M. Martin of Auchendennan; James Hope, Eastbarns; A. M. Gordon of Newton; Wellwood Maxwell of Kirkennan; J. D. Fletcher of Rosehaugh; and John Wilson, Chapelhill. *Extraordinary Directors*—Provost Scott, Dumfries; W. J. Maxwell, yr. of Munches, M.P.; A. Johnstone Douglas of Lockerbie; John M'Kie of Ernespie; John H. Dickson, Dabton; David Kirkpatrick, Amisfield; Robert F. Dudgeon, The Grange; W. Marshall, Lochfergus; James Drew, Doonhill; Thos. C. Greig, Rephad; David Wilson, yr. of Carbeth; John M. Aitken, Norwood; John Gilmour of Montrave; Patrick Stirling of Kippendavie; Lord Reay; Andrew Allan, North Kirkland; John Cran, Kirkton; Walter Elliot, Hollybush; W. S. Ferguson, Pictstonhill; and George R. Glendinning, Hatton Mains.

On the invitation of Sir James H. Gibson-Craig, his Grace the Duke of Buccleuch then took the chair.

The Noble CHAIRMAN said he had to return them his sincere and hearty thanks for the honour they had done him in electing him President of the Highland and Agricultural Society for a second time. He always took a deep interest in the Highland and Agricultural Society; and on this occasion, when the Show was to be held at Dumfries, he could assure them that no effort on his part would be spared to make their annual exhibition a most pronounced success.

### H.R.H. THE DUKE OF YORK, RETIRING PRESIDENT.

The SECRETARY submitted the following motion, which, it was proposed, should be passed and sent to the retiring President, H.R.H. the Duke of York, K.G.: "The members of the Highland and Agricultural Society of Scotland, in general meeting assembled, desire to convey their humble and hearty thanks to his Royal Highness the Duke of York, K.G., for the honour he has done the Society in having filled the office of President for the past two years. They also resolve to record their respectful appreciation of the interest his Royal Highness has taken in the National Society, and of the invaluable services he has rendered to it by his handsome contributions to the premiums for the Shows of 1893 and 1894, and more especially by visiting the Show at Aberdeen last year, and presiding at the general meeting of members in the show-yard there."

The CHAIRMAN said he begged to move this resolution, and in doing so he wished to recall to their recollection the great interest which his Royal Highness the Duke of York took in the Society. His Royal Highness was President for two years in succession. He was unable to be present the first year owing to his marriage taking place; but he very considerately consented to be elected for a second term, in the hope of being present at their Show. This happily took place, and the members in general knew what the result was.

The motion was agreed to most cordially.

### Financial Statement.

Mr James Auldjo Jamieson submitted the Accounts for the year 1893-94. They would be glad to know that the Society had had another successful year financially. The gross expenditure for the past year had been £10,458, and the income exceeded that amount by £2806. This, of course, is mainly the outcome of the great success of the Aberdeen Show, with its credit balance of over £1600; but the handsome results for the year are also in a large measure due to a saving of nearly £400 in establishment expenses, and to the fact that over 850 new members have been elected during the past two years.

### The Argyll Naval Fund.

Sir Robert Menzies, Bart., submitted the Accounts of the Argyll Naval Fund for 1893-94, which showed that the income for the year amounted to £256, 17s. 3d., from which six recipients received each an allowance of £40, making the total expenditure £240. Two vacancies had recently occurred in the list of recipients, by the promotion of C. W. Campbell Strickland, and the retirement from the service, on account of ill-health, of C. D. L. MacEwan. Mr Strickland had received the grant of £40 for six years, and Mr MacEwan £40 for four years. The following candidates had been appointed to the two vacant grants—viz.: John Henry Tod and Percy Lockhart H. Noble, both at present on the training ship Britannia. He moved the adoption of the report.

The Rev. John Gillespie seconded, and the motion was unanimously agreed to.

### The Aberdeen Show—A Success.

Sir James H. Gibson-Craig submitted the report on the Aberdeen Show of 1894. He referred to the visit of his Royal Highness the Duke of York to the Show on the second and third days, remarking that the Royal visit had aroused the heartiest enthusiasm, not only amongst the thousands who thronged the showyard, but also in the city of Aberdeen, and throughout the country generally. The Duke of York had evinced the liveliest interest in the entire proceedings in the showyard, and he was sure he was well justified in saying that the practical and kindly sympathy which his Royal Highness had thus manifested with the wellbeing of Scotch agriculture was warmly appreciated by the people of Scotland. He was sure that he only re-echoed the wish of the whole of the members of the Society when he hoped that it would not be long before his Royal Highness again honoured them with his presence at their Show. The Show of last year was the largest of the eight that have been held in Aberdeen, and was by far the most successful. The display of live stock and implements was of a very high character; the weather was favourable, and the attendance of the public remarkably large. The financial results were very gratifying. The net profit on the Show exceeds £1670, or about £1450 more than the profit on the Aberdeen Show in 1885. The Society was greatly indebted to the Local Committee and its convener, Mr Gordon of Newton, for their efforts in raising a sum of over £900 in aid of the funds of the Show. Of this sum, £100 was contributed by the Town Council of Aberdeen, and the Society was much indebted to the Council not only for this contribution, but also for the free use of the Links, and for their hearty and courteous co-operation in connection with the Show. In a special manner they were owing a debt of gratitude to Lord Provost Stewart for his untiring efforts to promote the success of the Show. He thought it right they should also acknowledge the very kindly co-operation they received from the Royal Northern Agricultural Society, which had contributed £100 towards the funds of the Show.

The Hon. G. Waldegrave Leslie desired to know what recommendation they were making with regard to light railways or other matters which might be calculated to alleviate the prevailing agricultural depression.

Sir James H. Gibson-Craig said he hardly saw what connection this subject could have with the Aberdeen Show. They did not have light railways in the showyard. The subject of light railways had, however, been before the Board; but the Directors did not consider it expedient to take up the subject until the report on light railways was issued by the Government. The Secretary had been given power to issue circulars calling a meeting if he thought such was necessary.

The Hon. Mr Leslie having offered some other remarks about the Royal Agricultural Society of England having issued circulars to its members in reference to the subject of light railways, and the advantage accruing from the construction of such lines in certain parts of the country, the subject dropped.

### The 1895 Show at Dumfries.

Sir James H. Gibson-Craig reported that the arrangements for the Annual Show, to be held at Dumfries on the 23d July next and three following days, were well advanced. They had secured a capital site for the Show, with a superior subsoil suited for such a purpose. Excellent arrangements were also made in connection with the providing of forage. He was glad to say that the County Councils of Dumfries, Kirkcudbright, and Wigtown had resolved to impose a voluntary assessment in aid of the Show, just as was done in former times by the Commissioners of Supply—an example which, he hoped, would be followed in other parts of the country, and which he commended to the attention of their friends in the Perth district, which would be visited next year. It had been remitted to a Committee to raise additional subscriptions in the Dumfries district, and he was glad to say the Town Council of Dumfries had headed the list with a donation of £75. He hoped the splendid results at Aberdeen would be a wholesome stimulus to their friends in the south-west. The prize-list had been almost definitely arranged, and, on the whole, it would be found to be a liberal one. Including handsome contributions from societies, breeders, and others, the value of the prizes exceeded £2400, or nearly £300 more than at the Dumfries Show in 1886. Acting mainly on the advice of the representatives of the Dumfries Show district, and of other dairying districts in the west, where technical education in dairying is already fully appreciated and well provided, the Board had decided not to have a working dairy in the Dumfries Show. They had instead arranged a very liberal prize-list for the produce of the dairy, no less than £74 being offered as prizes for butter and cheese, the prizes for cheddar cheese alone amounting to £40. As they were so far south, the Directors had decided not to offer at Dumfries prizes for Highland Industries. He reminded the meeting that special prizes of not less value than £10 could be received up till the 1st of March when the list closed finally.

Sir James H. Gibson-Craig, replying to Mr MacLellan, assured that gentleman and all present that everything possible would be done by way of making the best possible arrangement with the railway companies in reference to cheap fares. With reference to the showyard arrangements, the matter would be carefully considered by the stewards.

Mr Hutchison, Vice-Convener of Perthshire, was astonished that they were not to have a working dairy at Dumfries. He did not think that the Dumfries people were so perfect in dairying as not to require a working dairy. In not having a working dairy he thought their National Society was taking a backward step. If he was in order, he would move that the matter be remitted back to the Directors for further consideration.

The Rev. John Gillespie remarked that a working dairy was very costly, and he doubted if the game was worth the candle.

Mr Hutchison still thought it was a mistake not to have a working dairy. A National Society such as theirs should not grudge to lose a little money if it was doing good. They lost a lot of money in other directions without its doing much good.

Sir James H. Gibson-Craig said the matter had been fully discussed at the meeting of Directors, and they tried to meet the wishes of the people of the district, and not those of the theorists at the other end of Scotland. What they wished was valuable prizes for the industry in which they were interested, and that was cheese-making. They could not burn the candle at both ends, but they must try to make both ends meet. They had not always been successful in this matter, but they intended to try to be so in future.

Mr Marr, Cairnbrogie, said the working dairy in the showyard was of no real educational value. It was mostly used as a resort for those who desired to partake of strawberries and cream.

Mr Hutchison said he did not want to press his motion. He was glad to hear that the Dumfries people were so well up in dairying, but he was not quite sure about it.

Colonel Stirling of Kippendavie mentioned that he had voted against having a working dairy at Dumfries because the people of the district did not wish it. If it was desired to have a working dairy at Perth, he would certainly support any proposal for such if it was brought forward.

Mr Smith, the Scottish representative of the Dairy Supply Company, suggested that they should have a butter-making competition, and test the efficiency of the Dumfries people in that department of dairy work.

Sir James H. Gibson-Craig said they were giving £74 for prizes for dairy produce, and they could not expect that the Directors would spend more money in that direction.

The subject then dropped.

## Highland Industries.

Sir Robert Menzies, Bart., said that he had already given the Directors notice that he proposed to bring up the matter of Highland Industries. He hoped that they would find that he was not so far wrong in proposing that there should be prizes for these at the Dumfries Show. Originally the Society was a Highland Society, and it was subsequently that the agricultural element was introduced into it. He had no fault to find with the introduction of the agricultural feature. It was a very important branch of their work; but they were not justified in eradicating the Highland element, which, although a small one, was a very important one. Sir Robert then traced the history of the movement which led up to the Society devoting a grant of £50 for the encouragement of Highland Industries, and he pointed out that last year Shetland work alone sold to the tune of £100. If they did not have the grant every year, there would be a certain amount of doubt in the minds of the people as to whether the competition was to take place or not, and this would impede these industries. He begged to move that the grant of £50, formerly given for the encouragement of Highland Industries, should be continued.

Sir James H. Gibson-Craig said he must disclaim any intention on the part of the Directors of not doing what they could for the good of the poor people in the Highlands. They might, however, do the work in a much more satisfactory way than at present. Their Show was at Inverness in 1892, and it might be considered the capital of the Highlands. They then sold £53 worth of goods, and it took £75 to accomplish that. At Edinburgh they did a little better, selling £59 worth at an expense of £75. At Aberdeen the Scottish Home Industries Association took charge of the work, and £115 worth of goods was sold at a cost to the Society of £72. Still that did not seem to be satisfactory. He would suggest that they should give up the Highland Industries, and do something for the cottagers of the district in which the Show was held. This work should be put into the hands of the people who were acquainted with it. They might also give grants to societies that had an interest in such work. At Dumfries, nine years ago, there was not a single entry.

Sir Robert Menzies thought the decision of the Directors was a wrong one, and he should like to take the feeling of the meeting on the question.

Sir James H. Gibson-Craig said he wished to make a personal explanation. It had come to their ears, and it had also come to the ears of Mr Macdonald, that the discontinuation of the Highland Industries section was brought about to save the Secretary an amount of trouble. Now, he could tell them that that statement was utterly devoid of foundation.

Sir Robert Menzies's motion was not seconded.

## Alterations on By-Laws.

Sir James H. Gibson-Craig submitted for approval the alterations upon the by-laws adopted at the Directors' meeting on 5th December last.

Mr Marr, Cairnbrogie, seconded, and paid a fitting compliment to Sir James H. Gibson-Craig for the interest and ability he had displayed in connection with this matter.

The motion was adopted.

## District Shows.

The Master of Polwarth submitted the report on district competitions, showing that in 1894 277 districts participated in grants of money and medals, the total expenditure under this head amounting to £250. For the current year the Directors proposed the following grants: (1) Under section 1—thirteen districts for grants of £12 each for cattle, horses, and sheep, and six districts in intermediate competition with a grant of three medals to each; (2) under section 2—six districts for grants of £15 each for stallions; (3) twenty-three districts receiving two medals each in aid of premiums; (4) for ploughing competitions, 180 medals; and (5) for cottages and gardens, nineteen districts, two medals each. The Board also recommended the following special grants—viz.: £20 to the Kilmarnock Dairy Produce Show, £5 to the Shetland Agricultural Society, and £3 each to Orkney, South Uist, and North Uist. Two gold medals of the value of £10 each are offered for the erection and improvement of cottages. The total sum thus recommended to be given in 1895 amounts to £383, or £133 more than that expended in this department last year.

The report was adopted.

## The Chemical Department.

Mr Wilson of Carbeth, in the absence of the convener of Committee, stated that, as mentioned at last general meeting, the whole question of the future working of the

Chemical Department had been considered by a large Committee specially appointed for the purpose. That Committee had held numerous meetings throughout the year, had most fully and patiently discussed the subject, and had framed a schedule which was approved by the Board of Directors last month by a majority of 24 votes to 4. That scheme, it would be observed, only tied the hands of the Board to a very small outlay—namely, a fixed salary of £50 a-year to the Chemist, and one-half the fees for analyses made by him for members. These are the only two items of outlay actually fixed; no further outlays could be incurred without the sanction of the Board. The Board would be empowered to expend moderate sums upon local experiments, and for original research by the Chemist and Botanist, jointly or separately; but it was provided that upon all heads the Society's outlays in the department would not exceed £450 a-year, including the botanical work as well as the chemical.

Dr A. P. Aitken reported as follows upon the work of the Chemical Department during the past year:—

During the past year the number of field experiments conducted by various societies throughout the country under the regulation of the Chemical Department has been greater than hitherto, and also the number of those taking part in them. At the request of the Banffshire Agricultural Association the experiments of 1893, on the manuring of turnips, were repeated, with the expectation that, as the season of 1893 had been exceptionally dry and warm, that of 1894 might prove very different and elicit some further information. The conditions have been entirely different, and farmers in the north have come through what they regard as a most unfavourable season for the turnip crop. Despite the altered conditions, the general results are not very different from the former ones. Slag phosphate, which was somewhat backward in 1893, has improved its position, and showed its suitability for application in wet districts and wet seasons. The heavy rains had evidently caused considerable loss of soluble nitrogenous manures, so that the crops which received a double dose of nitrate of soda showed better than they had done on previous occasions. There are in all about sixty returns from the five Banffshire districts, and the results of each district will be reported upon separately. Another manurial experiment on the growth of turnips was tried in ten different districts of Aberdeenshire. Its object was to test the relative efficiency of the chief phosphates now in the market where ground to as nearly as possible the same state of fineness. The returns are as yet far from complete, and it would be premature to give any report at this time. The extreme lateness of the harvest and backwardness of agricultural work prevented many from sending the reports of these and the other experiments, including two upon the top-dressing of the oat crop, and one upon the manuring of the bean crop, undertaken by the Stirlingshire and Carse of Gowrie Societies. There are also experiments on the top-dressing of pastures, and a series of observations on the various grass plots at Pumpherston, where the station is now being grazed with cows and horses. A number of the plots are eaten quite bare, while others are almost entirely neglected by the stock. The experiments on finger-and-toe land have given results which are far from uniform, and the same may be said of the tests made of Driffield's disease-resisting turnip-seed. An experiment on a large scale, under the care of Mr Milne, is now going on at Mains of Laithers to test the relative efficiency of linseed-cake and distillery grains, and a mixture of the latter with decorticated cotton-cake, and also meat-meal and Russian barley, which are at present selling at a very low price. There are about fifty cattle employed in this investigation. A similar experiment with sheep is being tried at Ferney Castle by Mr Logan. Application has been made by the Carse of Gowrie Association to have analyses made of the chief varieties of turnips grown in the district; and the Directors have agreed to it, provided that the number of bulbs in each sample is forty or more, as former experience has shown that analyses made from a few turnips are not trustworthy. Since last general meeting an important addition has been made to the facilities afforded for obtaining a complete agricultural education in Edinburgh by the institution, within the University, of a lectureship on Agricultural Chemistry, and the University Court has done me the honour of appointing me first lecturer. I rejoice in the opportunity thus afforded me of communicating the results of my long experience and study of that subject to the rising generation.

The Hon. George Waldegrave Leslie said he was one of the heretics who did not believe in that Chemical Department, and he was glad to see that the Directors had brought down the expenditure from £750 to £450. He hoped that retrenchment would continue.

The Chairman said he supposed the chemical reports were approved of.

Mr Fyshe, Treaton, said they were not quite done with the Chemical Department. In the combined investigations which were spoken of in the report, the Botanist seemed to be saddled with an equal share of the work, while in the matter of salary the Chemist appeared to be the predominant partner. He failed to see why the Botanist, who did a very large amount of work for the Society, should only be paid

£25. Moreover, there was another official of the Society who deserved recognition in the way of payment—he referred to Principal Williams. If Dr Aitken was to get £3, 3s. a-day for going up and down the country, at the request of some of his farmer friends, to point out to them what their land was like, then he had no hesitation in saying that Principal Williams ought to be put on the same footing. He thought that the sum mentioned in the report should be equalised between the Botanist and Chemist, and that there should be no predominant partner.

Mr Wilson, Carbeth, said that they would notice by the report that the payment was to be according to the work done. Each scheme was to be approved of by the Chemical Committee and by the Board, and the Society might trust them for one year at least to fairly apportion the salary according to the work done. The other matter to which Mr Fyshe had referred—the remuneration of Principal Williams—was outside his sphere, but it might be brought before the Board whether that remuneration should be increased. At the same time, he thought he was right when he said that Principal Williams was not in the same position in reference to visiting country districts as was the Chemist. He did not think Principal Williams would be putting himself in a fair position if he went round the country and offered advise to farmers when there were professional brethren already doing the work. This was really a question of the Chemist being able to get into closer contact with the members of the Society than it was possible for him to be in the past. It was only proposed that the Chemist should go round the country in the first instance by way of experiment, and it was not a matter of £150, but of a third of that amount. That was not a great outlay in a case of this kind. Mr Wilson also pointed out the trouble that was experienced in sampling manures under the Fertilisers Act, and said that some farmers were still glad to get the work done by the Chemist of that Society.

Mr Peter Fyshe, Newtonlees, asked why the determining of one ingredient in manure should be charged 5s., while the determining of two ingredients was charged 10s. When a farmer sent a sample for analysis, he expected a full analysis. He saw, further, that in addition to this a report on the purity was to be charged extra. It would seem, therefore, that the analysis of manures and cakes by the Society Chemist was no cheaper than if the analysis had been done by any other Chemist.

Mr Wilson replied that if they sent samples that entailed double work, they would require to pay double price.

The Rev. John Gillespie said there was one important element which had not been referred to. It was, that unless the Society undertook a considerable amount of experimental work they would not get the grant of £200 from the Board of Agriculture. Hitherto the Board of Agriculture had approved of the Society's experiments, and they were so much satisfied with the result that they had continued the grant.

Mr W. S. Ferguson, Pictstonhill, said that unless they showed something for it they would not get the Government grant. Indeed, they must show that they were spending a considerable amount before they got anything at all. The Committee would do their utmost not to spend the £450 mentioned in the report. In connection with the projected scheme they would be paying for work that had actually been done; and in connection with it they hoped that the Botanist would earn more in the future than he had earned in the past.

Mr Guild, W.S., Edinburgh, said he should like to have a little more information as to how the £450 was proposed to be spent. It seemed that the £450 was to be taken entirely from the funds of the Society, and that there was in the background a further sum of about £250 which the Society might calculate on getting from the Government, so that in all they had about £700. ("No, no.") That was a very large sum, and they ought to be satisfied, before that expenditure was undertaken, that something like value in benefit was to be obtained from it. He did not for one moment wish to undervalue the services of Dr Aitken. That was beside the question. What the Society had to decide was whether in that particular department the funds were properly and economically spent. He was prepared to move that the vote of £450 referred to in the report should be reduced by £100.

Mr William Taylor, East Bank, Kinross, seconded.

Mr Wilson said he would be very glad indeed to supply more information, but he did not know how he could more fully explain. This, at any rate, he might say, that unless the Society spent a certain sum of money on experimental work, they would not get anything by way of grant from the Government. The Government had made that very plain indeed. It was all very well for Mr Guild to speak about an expenditure of £700, but unless the Society was able to show an expenditure of something like £450 they would not get the grant from the Government. They might rest assured that an expenditure of that kind would result in benefit to the Scottish farmer generally. At the same time the Committee did not propose to spend the whole amount unless they could see a good use to put it to.

The Master of Polwarth said there appeared to be still some misunderstanding as to the actual expenditure. The sum received from the Government last year was

£200; and, on the other hand, the total sum spent was £728. Therefore the actual sum spent on the Chemical Department was £528; and the members should keep in mind that the Committee had then spent £100 less than they had been authorised to spend. The Committee now proposed to spend a maximum of £450, but very likely the sum actually spent would be less. If the Society reduced its expenditure in that particular department very much, then the Government would also reduce the grant.

Some further discussion ensued, after which

The CHAIRMAN suggested that perhaps the best plan was to let it be a recommendation to the Committee to consider the points which had been raised, and that the meeting should not take any further action at the present moment. The Committee were now very fully informed of the views of the Society on the matter.

Mr GUILD accordingly withdrew his motion, and the reports were adopted.

### DAIRY DEPARTMENT.

Mr CROSS of Knockdon reported that in 1894 a sum of £80 had been expended under this department—viz., £60 to the Scottish Dairy Institute at Kilmarnock, and £20 to the Angus and Mearns Dairy School. For 1895 the Directors recommended that the grant of £60 be continued to the Scottish Dairy Institute.

The report was agreed to.

### FORESTRY DEPARTMENT.

Sir ROBERT MENZIES reported that during the year 1894, £173, 10s. had been received towards the endowment of the Forestry class in Edinburgh University. He moved that the usual grant of £50 to the Lecturer on Forestry in the University of Edinburgh be continued for this year. The examinations this year for the Society certificates in Forestry had been fixed by the Directors as follows: Written, 19th March; Oral, 22d March. The two intervening days were occupied with the written examinations in agriculture, so that now if any student wished to take up in the same year both the forestry and the agricultural examinations, he could do so. This, under the previous arrangements, was impracticable.

The report was adopted.

### AGRICULTURAL EDUCATION.

The Rev. JOHN GILLESPIE reported that the examinations for the Society's diploma and certificate in agriculture would this year be held as follows: Written, 20th and 21st March; Oral, 22d March. He had to ask the approval of the meeting to the following slight alterations on the by-laws for the examinations, viz.:—

1. By-law III.—Omit the closing words, "and that the oral examinations shall be "public."
2. By-law V.—In line 6 omit the words, "the examiners."
3. By-law VI.—In line 6 omit the words, "the examiners."

Mr HUTCHISON suggested that students should be known to the examiners by numbers and not by their names.

Principal WILLIAMS, speaking as one of the oldest examiners, said he did not think there could be any objection to the proposal.

The CHAIRMAN stated that the suggestion would be submitted to the Council on Education, whereupon the report was then agreed to.

### BOTANICAL REPORT.

Professor M'ALPINE gave in the following report:—

I have the honour to report that during the past year I have tested the purity and germinating power of over one hundred and twenty samples of grass and clover seeds.

Germination and purity were, as a rule, high, but during germination outbreaks of fungus often caused delay by making a re-test necessary.

There seems still to be a tendency to purchase tall fescue, and if this is preferred to the much cheaper meadow fescue, the purchaser ought to take special care that the tall fescue is genuine, and not the worthless New Zealand species—*Festuca arundinacea.*

Several inquiries reached me regarding the value of "hard clover-seeds": the percentage of these "hard seeds" was stated separately in the reports of clover tests, and not, as is often the case, taken into account, at least in part, as germinating seed.

Many experiments on germination have been made during the past year, and it is worthy of mention, as a point of practical importance in testing seeds, that a narrow strip of wood so placed between the folds of blotting-paper that air has freer access

to the seed, facilitates much the process of germination. Now I constantly place a common match, having the ends tipped with gutta-percha, between the folds of blotting-paper on which the seeds germinate.

Many farmers sent weeds and other plants for botanical determination, and often consulted regarding grass mixtures, the best and most suitable for their special circumstance.

### VETERINARY DEPARTMENT.

Mr ELLIOT, Holybush, convener of the Veterinary Committee, reported that Principal Williams was engaged upon investigations in regard to louping-ill amongst sheep, for which the Directors had voted a sum of £50. It was extremely gratifying to observe the continued comparative freedom of British farm live stock from those destructive contagious diseases which in former years had inflicted enormously heavy losses upon this country.

### ESSAYS AND REPORTS.

The Rev. JOHN GILLESPIE stated that the readers having reported unfavourably upon all the papers sent in last year, the Board was not in a position to award any premiums in this department at this time. The volume of the 'Transactions' for 1895 was in preparation, and he believed that, when issued, it would be found to be a volume of exceptional interest and value to the members of the Society.

On the motion of Mr CROSS a vote of thanks was accorded to the noble chairman for presiding.

# APPENDIX (A).

# PREMIUMS

OFFERED BY

# THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND IN 1895.

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## CONTENTS.

## PRIVILEGES OF MEMBERS

MEMBERS OF THE SOCIETY ARE ENTITLED—

1. *To receive on application a free copy of the 'Transactions' annually.*
2. *To apply for District Premiums that may be offered.*
3. *To report Ploughing Matches for Medals that may be offered.*
4. *To Free Admission to the Shows of the Society.*
5. *To exhibit Live Stock and Implements at reduced rates.**
6. *To have Manures and Feeding-Stuffs analysed at reduced fees.*
7. *To have Seeds tested at reduced fees.*
8. *To have Diseases affecting Farm Crops inquired into.*
9. *To attend and vote at General Meetings of the Society.*
10. *To vote for the Election of Directors, &c., &c.*

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### ANALYSIS OF MANURES AND FEEDING-STUFFS

The Fees of the Society's Chemist for Analyses made for Members of the Society shall, until further notice, be as follow:—

The estimation of *one* ingredient in a manure or feeding-stuff . . . . 5s.
The estimation of *two or more* ingredients in a manure or feeding-stuff . . . 10s.

*These charges apply only to analyses made for the sole and private use of Members of the Highland and Agricultural Society who are not engaged in the manufacture or sale of the substances analysed.*

If the sample represents a substance bought under a guarantee, and if it is found to be notably deficient, the Society will communicate with the vendor and endeavour to obtain compensation for the buyer.

The Society's Chemist also supplies valuations of manures, according to the Society's scale of units, in cases in which the cash price asked by the seller accompanies the sample.

### EXAMINING SEEDS, CROP DISEASES, &c.

The rates of charge for the examination of plants and seeds, crop diseases, &c., will be had on application to the Secretary.

### ELECTION OF MEMBERS

Candidates for admission to the Society must be proposed by a Member, and are elected at the half-yearly General Meetings in January and June. It is not necessary that the proposer should attend the Meeting.

### CONDITIONS OF MEMBERSHIP

The ordinary subscription is £1, 3s. 6d. annually, which may be redeemed by one payment, varying, according to the number of previous annual payments, from £7, 1s. to £12, 12s. Proprietors farming the whole of their own lands, whose rental on the Valuation Roll does not exceed £500 per annum, and all Tenant-Farmers, Secretaries or Treasurers of Local Agricultural Associations, Factors resident on Estates, Land Stewards, Foresters, Agricultural Implement Makers, and Veterinary Surgeons, none of them being also owners of land to an extent exceeding £500 per annum, are admitted on a subscription of 10s. annually, which may be redeemed by one payment, varying, according to the number of previous annual payments, from £3 to £5, 5s.† Subscriptions are payable on election, and afterwards annually in January.

Members are requested to send to the Secretary the names and addresses of Candidates they have to propose (stating whether the Candidates should be on the £1, 3s. 6d. or 10s. list).

JAMES MACDONALD, *Secretary.*

3 GEORGE IV. BRIDGE, EDINBURGH.

* Firms are not admitted as Members; but if one partner of a firm becomes a Member, the firm is allowed to exhibit at Members' rates.

† Candidates claiming to be on the 10s. list must state under which of the above designations they are entitled to be placed on it.

# ESTABLISHMENT FOR 1895.

## President.

THE DUKE OF BUCCLEUCH AND QUEENSBERRY, K.T.,
DRUMLANRIG CASTLE, THORNHILL.

## Vice-Presidents.

The EARL OF STAIR, K.T., Lochinch, Castle Kennedy Station.
Sir ROBERT JARDINE of Castlemilk, Bart., Lockerbie.
Sir MARK J. STEWART of Southwick, Bart., M.P., Ardwell, Wigtownshire.
WELLWOOD H. MAXWELL of Munches, Dalbeattie.

## Ordinary Directors.

R. SINCLAIR SCOTT, Burnside, Largs.
Sir ROBERT MENZIES of Menzies, Bart., Farleyer, Aberfeldy.
ROBERT PATERSON, Hill of Drip, Stirling.
Sir JAMES H. GIBSON-CRAIG of Riccarton, Bart., Currie.
JOHN MARR, Cairnbrogie, Old Meldrum.
Rev. JOHN GILLESPIE, Mouswald Manse, Ruthwell, R.S.O.
JONATHAN MIDDLETON, Clay of Allan, Fearn.
GIDEON POTT of Dod, Knowesouth, Jedburgh.
JOHN SPEIR, Newton Farm, Newton, Glasgow.
GEORGE DUN, Easter Kincaple, St Andrews.
Sir J. R. G. MAITLAND of Barnton, Bart., Craigend, Stirling.
JAMES I. DAVIDSON, Saughton Mains, Gorgie, Edinburgh.
W. H. LUMSDEN of Balmedie, Aberdeenshire.
ANDREW LUSK, Lochvale, Dumfries.
JOHN MACPHERSON GRANT, yr. of Ballindalloch, Milton Cottage, Kingussie.
JOHN SCOTT DUDGEON, Longnewton, St Boswells.
ALEXANDER CROSS of Knockdon, 19 Hope Street, Glasgow.
Captain CLAYHILLS HENDERSON of Invergowrie, R.N., Dundee.
W. T. MALCOLM, Dunmore Home Farm, Larbert.
Captain ROBERT DUNDAS, yr. of Arniston, Kirkhill, Gorebridge.
GEORGE COWE, Balhousie, Carnoustie.
JAMES LOCKHART, Mains of Airies, Stranraer.
C. M. CAMERON, Balnakyle, Munlochy.
The Hon. The MASTER OF POLWARTH, Humbie House, Upper Keith.
DAVID M'GIBBON, Ardnacraig, Campbeltown.
ANDREW HUTCHESON, Beechwood, Perth.
JOHN M. MARTIN of Auchendennan, Alexandria, N.B.
JAMES HOPE, East Barns, Dunbar.
ALEXANDER M. GORDON of Newton, Insch, Aberdeenshire.
WELLWOOD MAXWELL of Kirkennan, Dalbeattie.
J. D. FLETCHER of Rosehaugh, Inverness.
JOHN WILSON, Chapelhill, Cockburnspath.

## Extraordinary Directors.

John Luke Scott, Provost of Dumfries.
W. J. Maxwell, yr. of Munches, M.P., Terraughtie, Dumfries.
A. Johnstone Douglas, Comlongan Castle, Ruthwell, R.S.O.
John M'Kie of Ernespie, Castle-Douglas.
John H. Dickson, Dabton, Thornhill.
David Kirkpatrick, Townfoot, Amisfield, Dumfries.
R. F. Dudgeon, The Grange, Kirkcudbright.
William Marshall, Lochfergus, Kirkcudbright.
James Drew of Craigencallie, Doonhill, Newton-Stewart.
Thomas C. Greig, Rephad, Stranraer.
David Wilson, yr. of Carbeth, Killearn.
Andrew Allan, North Kirkland, Dalry, Ayrshire.
John Cran, Kirkton, Bunchrew, Inverness.
John M. Aitken, Norwood, Lockerbie.
John Gilmour of Montrave, Leven, Fife.
Patrick Stirling of Kippendavie, Dunblane.
Lord Reay, Carolside, Earlston.
Walter Elliot, Hollybush, Galashiels.
W. S. Ferguson, Pictstonhill, Perth.
George R. Glendinning, Hatton Mains, Kirknewton.

## Office-Bearers.

Sir William Stuart Walker, K.C.B., *Treasurer.*
Sir G. Graham Montgomery of Stanhope, Bart., *Honorary Secretary.*
James Macdonald, F.R.S.E., *Secretary.*
Rev. Archibald Scott, D.D., *Chaplain.*
Andrew P. Aitken, D.Sc., 8 Clyde Street, *Chemist.*
William Home Cook, C.A., *Auditor.*
Tods, Murray, & Jamieson, W.S., *Law Agents.*
A. N. M'Alpine, 60 John Street, Glasgow, *Consulting Botanist.*
James D. Park, *Practical Engineer.*
John Macdiarmid, *Clerk.*
Edward M. Cowie, *Second Clerk.*
William Williams, F.R.C.V.S., *Professor of Veterinary Surgery.*
William Blackwood & Sons, *Printers and Publishers.*
Keith & Co., 65 George Street, *Advertising Agents.*
G. Waterston & Sons, *Stationers.*
James Crichton & Co., *Silversmiths and Medallists.*
John Watherston & Sons, *Inspectors of Works.*
William Simpson, *Messenger.*

## Chairman of Board of Directors.

Sir James H. Gibson-Craig, Bart.

## Chairmen of Committees.

1. *Argyll Naval Fund,* . . . Captain G. D. Clayhills Henderson.
2. *Finance, Chambers, and Law,* James Auldjo Jamieson, W.S.
3. *Publications,* . . . . . Rev. John Gillespie, Mouswald Manse.
4. *Shows,* . . . . . . Sir James H. Gibson-Craig, Bart.
5. *Science,* . . . . . . David Wilson, yr. of Carbeth.
6. *General Purposes,* . . . Sir James H. Gibson-Craig, Bart.

**General Meetings.**—By the Charter the Society must hold two General Meetings each year, and, under ordinary circumstances, they are held on the third Wednesday of the months of January and June, at one o'clock, in the Society's Hall, 3 George IV. Bridge, for the election of Members and other business. Twenty a quorum.

By a resolution of the General Meeting on 15th January 1879, a General Meeting of Members is held in the Showyard on the occasion of the Annual Show. This year it will be held at Dumfries, on Wednesday, 24th July, an hour to be announced in the programme of the Show.

With reference to motions at General Meetings, Bye-Law No. 10 provides—"That at General Meetings of the Society no motion or proposal (except of mere form or courtesy) shall be submitted or entertained for immediate decision unless notice thereof has been given a week previously to the Board of Directors, without prejudice, however, to the competency of making such motion or proposal to the effect of its being remitted to the Directors for consideration, and thereafter being disposed of at a future General Meeting."

**General Show at Dumfries**—23d, 24th, 25th, and 26th July.—Entries close for Implements, 21st May—Stock, Poultry, and Dairy Produce, 18th June.

**Directors' Meetings.**—The Board of Directors meet on the first Wednesday of each month from November till June inclusive, at half-past one o'clock P.M., and occasionally as business may require, on a requisition by three Directors to the Secretary, or on intimation by him. Seven a quorum.

**Nomination of Directors.**—Meetings of Members, for the purpose of nominating Directors to represent the Show Districts on the Board, will be held at the places and on the days after mentioned:—

| | |
|---|---|
| 1. Glasgow, North British Station Hotel, . | Wednesday, 31st July, at 1. |
| 2. Perth, Salutation Hotel, . . . . | Friday, 2d August, at 2. |
| 3. Stirling, Golden Lion Hotel, . . . | Friday, 16th Aug., at 1.30. |
| 4. Edinburgh, 3 George IV. Bridge, . . | Wednesday, 21st Aug., at 2. |
| 5. Aberdeen, Imperial Hotel, . . . | Friday, 23d Aug., at 12. |
| 6. Dumfries, King's Arms Hotel, . . | Wednesday, 28th Aug., at 1. |
| 7. Inverness, Caledonian Hotel, . . . | Friday, 30th Aug., at 12.30. |
| 8. Kelso, Secretary's Tent, Ram Sale Ground, | Friday, 13th Sept., at 1. |

The nomination of Proprietors or other Members paying the higher subscription must be made in the 1st, 2d, 4th, and 8th Districts; and the nomination of Tenant-Farmers or other Members paying the lower subscription, in the 3d, 5th, 6th, and 7th Districts.

**Committee Meetings.**—Meetings of the various Committees are held as required.

**Examinations for the Society's Diploma and Certificate** in Agriculture and Certificates in Forestry are fixed to be held as follows: Forestry written, 19th March; Agricultural written, 20th and 21st March; Oral, both subjects, 22d March.

# COMMITTEES FOR 1895.

## 1. ARGYLL NAVAL FUND.

Capt. G. D. CLAYHILLS HENDERSON of Invergowrie, R.N., Dundee, *Convener.*
Sir DAVID BAIRD of Newbyth. Bart., Prestonkirk.
Sir ROBERT MENZIES of Menzies, Bart., Farleyer, Aberfeldy.
DAVID M'GIBBON, Ardnacraig, Campbeltown.
JOHN MACLACHLAN of Maclachlan, 12 Abercromby Place, Edinburgh.

## 2. FINANCE, CHAMBERS, AND LAW.

JAMES AULDJO JAMIESON, W.S., 66 Queen Street, Edinburgh, *Convener.*
Sir JAMES H. GIBSON-CRAIG of Riccarton, Bart., *Vice-Convener.*
Rev. JOHN GILLESPIE, Mouswald Manse, Ruthwell, R.S.O.
PATRICK STIRLING of Kippendavie, Dunblane.
G. R. GLENDINNING, Hatton Mains, Kirknewton.
JOHN SCOTT DUDGEON, Longnewton, St Boswells.
ALEXANDER CROSS of Knockdon, 19 Hope Street, Glasgow.
A. M. GORDON of Newton, Insch, Aberdeenshire.
Sir WILLIAM S. WALKER, K.C.B., 5 Manor Place, *ex officio.*
Sir G. GRAHAM MONTGOMERY of Stanhope, Bart., Stobo Castle, *ex officio.*
WILLIAM HOME COOK, C.A., Auditor, *ex officio.*

## 3. PUBLICATIONS.

Rev. JOHN GILLESPIE, Mouswald Manse, Ruthwell, R.S.O., *Convener.*
Dr A. P. AITKEN, 8 Clyde Street, Edinburgh.
Dr CLEGHORN of Stravithy, St Andrews.
R. G. WARDLAW RAMSAY, Tillicoultry House, Tillicoultry.
JOHN SCOTT DUDGEON, Longnewton, St Boswells.
JOHN SPEIR, Newton Farm, Newton, Glasgow.
DAVID WILSON, yr. of Carbeth, Killearn.
Sir JAMES H. GIBSON-CRAIG, Bart., *ex officio.*

## 4. SHOWS.

Sir JAMES H. GIBSON-CRAIG of Riccarton, Bart., Currie, *Convener.*
JOHN M. MARTIN of Auchendennan, Balloch, *Vice-Convener.*
Sir ROBERT MENZIES of Menzies, Bart., Farleyer, Aberfeldy.
PATRICK STIRLING of Kippendavie, Dunblane.
JOHN CRAN, Kirkton, Bunchrew, Inverness.
WALTER ELLIOT, Hollybush, Galashiels.
Rev. JOHN GILLESPIE, Mouswald Manse, Ruthwell, R.S.O.
JOHN GILMOUR of Montrave, Leven.
W. H. LUMSDEN of Balmedie, Aberdeen.
JOHN MARR, Cairnbrogie, Old Meldrum.
JAMES LOCKHART, Mains of Airies, Stranraer.
The Hon. The MASTER OF POLWARTH, Humbie House, Upper Keith.
JONATHAN MIDDLETON, Clay of Allan, Fearn.
R. SINCLAIR SCOTT, Burnside, Largs.

W. S. Ferguson, Pictstonhill, Perth.
George Dun, Easter Kincaple, St Andrews.
Alex. M. Gordon of Newton, Insch, Aberdeenshire.
Alex. Cross of Knockdon, 19 Hope Street, Glasgow.
Andrew Hutcheson, Beechwood, Perth.
John Scott Dudgeon, Longnewton, St Boswells.
W. T. Malcolm, Dunmore Home Farm, Larbert.
G. R. Glendinning, Hatton Mains, Kirknewton.
J. D. Fletcher of Rosehaugh, Inverness.
James Hope, East Barns, Dunbar.
C. M. Cameron, Balnakyle, Munlochy.
James D. Park, Engineer, *ex officio.*
John Macpherson Grant, yr. of Ballindalloch, Milton Cottage, Kingussie.

## 5. SCIENCE.

David Wilson, yr. of Carbeth, Killearn, *Convener.*
Jonathan Middleton, Clay of Allan, Fearn, Ross-shire, *Vice-Convener.*
G. R. Glendinning, Hatton Mains, Kirknewton.
R. Shirra Gibb, Boon, Lauder.
The Hon. The Master of Polwarth, Humbie House, Upper Keith.
W. S. Ferguson, Pictstonhill, Perth.
George Henderson, Upper Keith.
John Speir, Newton Farm, Newton, Glasgow.
George Cowe, Balhousie, Carnoustie.
John Scott Dudgeon, Longnewton, St Boswells.
Andrew Hutcheson, Beechwood, Perth.
Alex. Cross of Knockdon, 19 Hope Street, Glasgow.
Rev. John Gillespie, Mouswald Manse, Ruthwell, R.S.O.
Sir Robert Menzies of Menzies, Bart., Farleyer, Aberfeldy.
John Wilson, Chapelhill, Cockburnspath.
Captain Robert Dundas, yr. of Arniston, Kirkhill, Gorebridge.
Lord Reay, Carolside, Earlston.
John Gilmour of Montrave, Leven, Fife.
Dr Aitken, Chemist, *ex officio.*
A. N. M'Alpine, Botanist, *ex officio.*
Professor Williams, *ex officio.*
Sir James H. Gibson-Craig of Riccarton, Bart., *ex officio.*

## 6. GENERAL PURPOSES.

Sir James H. Gibson-Craig of Riccarton, Bart., Currie, *Convener.*
The Hon. The Master of Polwarth, Humbie House, Upper Keith.
G. R. Glendinning, Hatton Mains, Kirknewton.
Alex. M. Gordon of Newton, Insch, Aberdeenshire.
Rev. John Gillespie, Mouswald Manse, Ruthwell, R.S.O.
James Hope, East Barns, Dunbar.
John M. Martin of Auchendennan, Balloch.

The President, Vice-Presidents, the Treasurer, Honorary Secretary, and Chairman of Directors are members *ex officio* of all Committees.

# AGRICULTURAL EDUCATION

## CERTIFICATE AND DIPLOMA IN AGRICULTURE.

### COUNCIL ON EDUCATION.

By a Supplementary Charter under the Great Seal, granted in 1856, the Society is empowered to grant Diplomas.

*Members of Council named by Charter.*

The PRESIDENT of the HIGHLAND AND AGRICULTURAL SOCIETY—*President.*
The LORD JUSTICE-GENERAL—*Vice-President.*

The LORD ADVOCATE.
The DEAN OF FACULTY.
The PROFESSOR OF AGRICULTURE.
The PROFESSOR OF ANATOMY.
The PROFESSOR OF BOTANY.
The PROFESSOR OF CHEMISTRY.
The PROFESSOR OF NATURAL HISTORY.

*Members of Council nominated by Society.*

The MASTER OF POLWARTH.
Sir JAMES H. GIBSON-CRAIG of Riccarton, Bart.
R. G. WARDLAW RAMSAY of Whitehill.
W. J. MAXWELL, yr. of Munches, M.P., Terraughtie, Dumfries.
Rev. JOHN GILLESPIE, Mouswald, Ruthwell, R.S.O.
JOHN MARR, Cairnbrogie, Old Meldrum.
ALEXANDER CROSS of Knockdon.

*Standing Acting Committee.*

The LORD JUSTICE-GENERAL—*Convener.*

The PROFESSOR OF AGRICULTURE.
The PROFESSOR OF BOTANY.
The PROFESSOR OF CHEMISTRY.
Rev. JOHN GILLESPIE of Mouswald.
R. G. WARDLAW RAMSAY of Whitehill.

*Board of Examiners.*

*Science and Practice of Agriculture.*—Professor WALLACE, University, Edinburgh; JAMES HOPE, East Barns, Dunbar; JAS. BIGGAR, yr. of Chapelton, Dalbeattie; and Professor WRIGHT, Glasgow and West of Scotland Technical College, 38 Bath Street, Glasgow.

*Botany.*—Dr CLEGHORN of Stravithy, St Andrews, and Professor A. N. M'ALPINE, Glasgow.

*Chemistry, Physics, and Agricultural Chemistry.*—Dr A. P. AITKEN, Edinburgh, and Dr WILLIAM CRAIG, Edinburgh.

*Natural History.*—Professor COSSAR EWART, Edinburgh, and Dr RAMSAY H. TRAQUAIR, Edinburgh.

*Veterinary Science.*—Professor WILLIAMS, Edinburgh, and FINLAY DUN, F.R.C.V.S., Edinburgh.

*Field-Engineering.*—DAVID ALAN STEVENSON, C.E., Edinburgh, and A. W. BELFRAGE, C.E., Edinburgh.

*Book-keeping.*—WILLIAM HOME COOK, C.A., Edinburgh, and J. WILSON BRODIE, C.A., Edinburgh.

The maximum number of marks in each subject is 100. In Agriculture, 75 marks qualify for Diploma and 60 for Certificate; in other subjects, 60 for Diploma and 40 for Certificate.

If a Candidate fail for the Diploma in Agriculture, or in more than two of the other subjects, he must take the entire Examination again; if he has obtained Diploma marks in Agriculture and failed in not more than two of the other subjects, he may come up again for examination in these subjects alone.

## BYE-LAWS.

I. That, in terms of the Charter, the Society shall nominate seven members to act on the Council on Education.

II. That the Council shall appoint a Board of Examiners on the following subjects :—Science and Practice of Agriculture ; Botany ; Chemistry ; Natural History ; Veterinary Science ; Field-Engineering ; and Book-keeping.

III. That the examinations shall be both written and oral, and that the value of the answers shall be determined by numbers.

IV. That there shall be two examinations,[1] to be styled respectively the "First-Class Certificate Examination" and the "Diploma Examination."

V. That to pass the "First-Class Certificate Examination," a candidate must be acquainted with the science and practice of agriculture, botany, chemistry, natural history, veterinary science, field-engineering, and book-keeping ; and that a certificate in the following terms, bearing the corporate seal and arms of the Society, signed by the President or Vice-President of the Council on Education and by the Secretary, shall be granted to candidates passing this examination :—

"These are to certify that on the , A. B. was examined, and has been found to possess a knowledge of the science and practice of agriculture, botany, chemistry, natural history, veterinary science, field-engineering, and book-keeping."

VI. That to pass the "Diploma Examination," a candidate must possess a *thorough knowledge* of the science and practice of agriculture, botany, chemistry, natural history, veterinary science, field-engineering, and book-keeping ; and that a diploma in the following terms, bearing the corporate seal and arms of the Society, and signed by the President or Vice-President of the Council on Education and by the Secretary, shall be granted to candidates passing this examination :—

"These are to certify that on the , A. B. was examined, and has been found to be proficient in the science and practice of agriculture, botany, chemistry, natural history, veterinary science, field-engineering, and book-keeping."

VII. That each successful candidate for the Society's Agricultural Diploma shall thereby become eligible to be elected a free life member of the Society.

VIII. That a Standing Acting Committee of the Council on Agricultural Education shall be appointed by the Directors.

*Note.*—The names of Diploma Free Life Members will be found in the list of Members of the Society.

The list of those who, up till 1893, had obtained the First-Class Certi-

[1] The examinations will be held in 1896 about the end of March.

ficate appears in vol. v., fifth series (1893), of the 'Transactions.' The following have since obtained

### FIRST-CLASS CERTIFICATES.

| | | | |
|---|---|---|---|
| 1894. | David Blair, Bankfoot, Inverkip. | | |
| 1894. | B. R. S. Prichard, Brislington, Bristol. | | |
| 1895. | Robert Allan, Halfway House, Whitburn. | | |
| 1895. | James Barron, Agricultural College, Aspatria. | | |
| 1895. | Wm. Cook Brackenridge, | do. | do. |
| 1895. | David Dickinson, | do. | do. |
| 1895. | Robert Hewison, | do. | do. |
| 1895. | John Luker, | do. | do. |
| 1895. | Joseph Henry Townshend, | do. | do. |
| 1895. | David Donald, Whiteinch. | | |
| 1895. | James Duthie Johnston, Mossbank, Fettercairn. | | |
| 1895. | James M'Creath, Auchenwinn, Maybole. | | |
| 1895. | F. J. Walkington, Greythorn, Kingstown. | | |
| 1895. | Sydney Edwards Pougnet, Edinburgh. | | |

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# SYLLABUS OF EXAMINATION

## FOR DIPLOMA AND CERTIFICATE.

### I.—SCIENCE AND PRACTICE OF AGRICULTURE.

1. *Geology.*—Geological strata—surface geology—formation of soils—their classification—physical characters and composition—suitability for cultivation.

2. *Drainage, &c.*—The principles on which drainage, irrigation, and warping operations should be based and carried out.

3. *Top-dressing.*—The application of lime—marl—clay, &c.

4. *Rotations.*—The principle of rotations—rotations suitable for different soils—systems of farming.

5. *Manures.*—The composition of manures—general and special—amounts used per acre—period and mode of application.

6. *Food-stuffs.*—The composition of feeding substances—their suitability for different classes of farm stock—considerations affecting their use.

7. *Crops.*—"How crops grow"—our farm crops—their cultivation, including cleaning, harvesting, and storage—diseases—insect injuries and remedies. The formation and management of plantations.

8. *Ensilage.*—Sweet and sour silage—different forms of silos and systems of ensilage.

9. *Weather.*—Meteorology, or the laws of climate as affecting plant-life—the influence of light and heat on cultivation—of absorption and retention of heat and moisture—of porosity and capillarity in soils.

10. *Live Stock.*—The breeding, rearing, feeding, and general treatment of farm stock—the different breeds of horses, cattle, sheep, and pigs—their characteristics—the districts where they are generally met with.

11. *Machinery.*—The machines and implements used in farming—their uses, prices, and the principal points to be attended to in their construction.

12. *Mechanical Powers.*—The "prime movers," or sources of power used in agriculture: man—horse—wind—water—steam—their relative values and advantages.

13. *Farming Capital.*—Calculations of the cost of stocking and working arable, stock, and dairy farms.

*Text-books.*—Stephens' 'Book of the Farm,' William Blackwood & Sons, Edinburgh and London; Pringle's 'Live Stock of the Farm,' William Blackwood & Sons; Wallace's 'Farm Live Stock of Great Britain,' Crosby Lockwood & Son; M'Connell's 'Agricultural Facts and Figures,' Crosby Lockwood & Son; 'Our Farm Crops,' Blackie & Son; 'How Crops Grow,' Macmillan & Co.; Warington's 'Chemistry of the Farm,' Vinton & Co., Limited, London; M'Alpine's 'Grasses'; Geikie's 'Outlines of Geology.'

## II.—BOTANY.

1. *Nutritive Organs of Plants.*—Root, stem, leaves. Functions of roots. Various kinds of stem, with examples. Use of the stem. Structure of leaves. Different kinds of leaves. Arrangement and functions of leaves.

2. *Reproductive Organs.*—Flower and its parts. Arrangements of the whorls of the flower—calyx, corolla, stamens, pistil. Ovule. Mature pistil or fruit. Pruning and grafting. Seed. Young plant or embryo. Sprouting of the seed, or germination.

3. *General Principles of Classification.*—Meaning of the terms Class, Order, Genus, and Species. Illustrations of natural orders taken from plants used in agriculture, such as grain crops, grasses, clovers, vetches, turnips, mangel-wurzel, peas, beans, &c. Practical examination in fresh specimens and models; some of the latter may be seen in the Museum at the Royal Botanic Garden, which is open daily to the public, free.

*Text-book.*—Balfour's 'Elements of Botany,' A. & C. Black.

## III.—CHEMISTRY AND PHYSICS.

*Physics.*

*Matter.*—Essential properties. Measurement of mass and capacity—decimal system. Solids, general properties. Liquids—capillarity, osmosis, hydrostatic law. Gases—density, diffusion, barometer, Boyle's law, Charles's law.

*Energy.*

Transformation and Conservation of energy. Heat—temperature, thermometer, conduction, convection, radiation, mechanical equivalent of heat. Light—refraction, polarisation, the spectrum.

*Chemistry.*

Processes—solution, filtration, sublimation, distillation, crystallisation, dialysis. Fundamental laws—constant proportion, multiple proportion, Avogadro's law, periodic law. Classification of the elements—characteristics of the commoner elements. Water—natural waters, their common impurities, soft and hard waters, water storage, water purification, composition, analysis, hydrates, steam, latent heat of water and steam. Hydrogen. Oxygen, oxides. Acids, bases, salts. Nitrogen, ammonia, nitric acid, nitrates and nitrites. The atmosphere—relation to animal and vegetable life. Chlorine—hydrochloric acid, chlorides, hypochlorites, bleaching-powder, bleaching, disinfection, chlorates. Bromine, iodine, and fluorine, and their chief compounds. Sulphur, sulphuretted hydrogen, sulphuric acid and sulphates, sulphurous acid, sulphites, and thiosulphates. Phosphorus, oxides of phosphorus, phosphates. Borates and silicates. Carbon, its oxides, carbonates, carbon disulphide. Hydrocarbons, chloroform, alcohols, ether, aldehyde, amines and amides, formic, acetic, oxalic, lactic, tartaric, and citric acids and their commonest salts. Glycerol, saponification. Distillation of wood

and coal. Benzene, anilin, carbolic acid, benzoic acid, turpentine. Hydrocyanic acid, cyanides, cyanates. Urea, uric and hippuric acids.

The following metals, their ores, metallurgy, oxides, and more important salts—potassium, sodium, barium, calcium, magnesium, aluminium, zinc, manganese, iron, chromium, bismuth, antimony, arsenic, lead, copper, mercury, silver, tin, platinum.

The chief tests for these metals and for the following acids—sulphuric, sulphurous, phosphoric, carbonic, hydrochloric, nitric, acetic, and oxalic. Alkaloids, morphin, quinin, strychnin.

## IV.—AGRICULTURAL CHEMISTRY.

1. *Soils.*—Their origin, formation, and classification. The physical and chemical properties of soils, and their improvement by physical and chemical means—their relation to air and water. Nitrification and the biology of the soil.

2. *Plants.*—The mineral and organic constituents of plants. The substances required for plant nutrition, and their relative importance. The chemical processes occurring in the germination, growth, and maturation of plants. Albuminoids, amides, and amido acids. Carbohydrates—sugars, starch, cellulose, pentoses. Fermentations—alcoholic, acetic, lactic, and butyric. Plant decay.

3. *Manures.*—Farmyard manure—its composition, improvement, and conservation. Fertilisers—their classification, composition, uses, and abuses—their mutual compatibility—their suitability for different crops and for different soils. The investigation and analysis of fertilisers, and their valuation and economic application. The conducting of manurial experiments.

4. *Crops.*—The chemical composition of the more important crops, and their mutual relations. The science of rotations. Symbiosis.

5. *Fodders.*—The general composition of the different classes of fodder crops. The circumstances affecting the nutritive value and digestibility of fodders. The injuries and impurities to which they are liable. The analysis and investigation of fodders. The detection of impurities in concentrated fodders.

6. *Animal Nutrition.*—The main facts regarding respiration and digestion. The production of flesh, fat, and bone. The nutrient ratio as a guide in stock-feeding. The calculation of dietaries. The relation of food to the age, condition, and progress of stock, and also to work. The conducting of feeding experiments.

7. *Dairy Produce.*—The chemical composition of milk. The testing and analysis of milk. The circumstances affecting milk production. Milk preservation. The composition of butter and cheese, and the chemical and physical conditions requisite for the production of butter and cheese of good quality. The sophistications of dairy produce and their detection. The diseases of milk and cheese, and the means of preventing their occurrence. The general scientific conduct of the dairy.

8. *The Relation of Food to Manure.*—The quality of manure derived from different kinds of stock, according to age, use, and feeding. Circumstances affecting the value of manures derived from feeding. The estimation of unexhausted fertility under different systems of feeding, manuring, and cropping.

*Text-books.*—Roscoe's 'Lessons in Elementary Chemistry,' Macmillan & Co., London, price 4s. 6d.; Johnston and Cameron's 'Elements of Agricultural Chemistry and Geology,' William Blackwood & Sons; Johnston's 'How Crops Grow,' Macmillan & Co., London; Warington's 'Chemistry of the Farm,' Vinton & Co., Limited, London.

## V.—NATURAL HISTORY.

### 1. Zoology.

1. The characters distinguishing the primary divisions of the Animal Kingdom.

2. A general knowledge of British Mammals, Birds, and Fresh-water Fishes. A more special knowledge of the natural history of the domestic animals and their parasites.

3. The classification of insects, and a knowledge of those which are injurious to crops.

*Text-book.*—Nicholson's 'Introductory Text-Book of Zoology,' William Blackwood & Sons, Edinburgh and London.

### 2. Geology.

1. A general knowledge of the chemical composition and physical characters of the rock-forming minerals, and of the composition and mode of occurrence of the common rocks. The changes in rocks and minerals induced by weathering.

2. The terms (Dip, Strike, &c.) used in descriptive field Geology.

3. A general knowledge of the great geological formations, with their characteristic fossils.

4. The geological sources of the leading economic mineral products.

5. Influence of the geological structure of a country on the configuration of the land and the composition of the soil.

*Text-books.*—Page's 'Introductory Text-Book of Geology' and Lyell's 'Students' Elements of Geology.'

## VI.—VETERINARY SCIENCE.

1. Anatomy of the digestive organs of horse, ox, and sheep, including their structural differences.

2. The digestive processes and principles of nutrition in the above animals.

3. A general knowledge of the blood and its circulation, and the processes of respiration, secretion, and excretion.

4. The physiology of reproduction, and its bearings on healthy breeding.

5. The period of utero-gestation in the mare, cow, ewe, and sow, and the special management of these animals prior to, at the time of, and after parturition.

6. The feeding and general management of farm stock.

7. Their more common diseases, with the general principles of treatment.

*Text-books.*—'Youatt on Sheep,' price 7s. 6d.; Steel's 'Diseases of the Ox,' price 15s.; Williams's 'Principles and Practice of Veterinary Surgery,' price 30s.; Williams's 'Principles and Practice of Veterinary Medicine,' price 30s.

## VII.—FIELD-ENGINEERING.

1. Land-surveying with the chain.

2. Mensuration of areas of land, in imperial and Scotch acres, from a chain survey or from a plan.

3. Levelling with the ordinary levelling instrument and staff, and calculating levels and gradients.

*Text-book.*—'Rudimentary Treatise on Land and Engineering Surveying,' by T. Baker, C.E., Weale's Series, price 2s. Part i. chaps. 1, 2, 3, and 6, and part ii. chap. 1, to be read.

## VIII.—BOOK-KEEPING.

1. Questions in Practice and Proportion.
2. Book-keeping—Describe books to be kept; give examples—taking of stock.

*Text-book.*—Stephens' 'Practical System of Farm Book-keeping,' William Blackwood & Sons, Edinburgh, price 2s. 6d.

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# EXAMINATION PAPERS, 1895.

## AGRICULTURE.

1. Given an arable farm of 600 acres—400 acres of which are in grass—200 being old pasture, and 200 having been recently laid down with a mixture of seeds of permanent pasture grasses, clovers, &c.—in a district well suited for sheep, and in which cattle can be fattened on the grass. The 200 acres of land under cultivation to be fully utilised by catch-cropping with a view to keeping a large stock of farm animals:—State (1) the rotation of crops you would adopt, (2) the numbers and descriptions of stock to be kept, (3) the amount of food for stock the farm would produce—all being consumed on the holding, (4) the numbers and prices of the animals sold during the year, (5) the amount of farmer's capital necessary, and (6) the financial position at the end of the year.

   *N.B.*—It is necessary to state the rent per acre; to name the breeds of animals which you select; and to mention the district in which the farm is situated.

2. What dangers to the farmer are involved in a prolonged and severe frost, such as prevailed during the early part of the current year? What precautions should the farmer take to avoid inconvenience and pecuniary loss when frost comes? What advantages result to the farmer from a spell of hard frost?

3 Describe in detail how you would proceed to drain a 20-acre level field of medium loam. State depth and distance apart of drains, and give a detailed calculation of the probable cost per acre.

4. Give a list of the corn crops commonly grown in Britain. State for each *a*) the usual time of sowing, (*b*) the quantity of seed, and (*c*) the average produce per acre.

   Point out the conditions and methods of cultivation that are most favourable to the production of good barley crops yielding good samples of grain.

5. Give details of the preparation of land for, and the sowing and management of a turnip crop on both light and heavy soils, and the various ways of securing the crop so as to have supplies available for sheep and cattle till, say, 20th April.

6. Give the names of the chief breeds of cattle in Great Britain and Ireland, and say which may be looked on as beef breeds and which as dairy cattle. Give also any crosses which you know to be popular for either purpose.

7. Detail the best way of preparing the land for a potato crop, the time of planting, the quantity of seed required, the best kinds of manures to apply, also the best mode of cleaning the crop during summer, and how the crop should be stored at lifting time so as to keep them until the following spring.

8. Entering to a farm near Edinburgh of 300 acres at Martinmas which had been farmed on a six-course shift,—namely, grass, oats, potatoes, wheat, turnips, and barley,—detail how you would proceed as to stocking the farm, what number of men and horses you would require; also give a general account of what the management should be as to preparing the land and putting in your first crop, &c.

(*Three hours allowed.*)

## BOTANY.

1. Explain as fully as you can the botanical nature of the part or parts which you would sow in order to produce the following plants: (*a*) turnip, (*b*) mangel, (*c*) wheat, (*d*) oat.

2. Explain how an oat-plant absorbs from soil (*a*) water, (*b*) nitrate of soda, (*c*) insoluble phosphate of lime.

3. Write out a botanical classification of the mangel-wurzel.

4. Compare the fruits of turnip and bean.

(*An hour and a half allowed.*)

## CHEMISTRY.

1. Given the following substances, how would you prepare alum from them?—pipe-clay, potashes, sulphuric acid.

2. Show, by means of equations, what changes occur to the following substances when heated: gypsum, green vitriol, blue vitriol, acetate of lime, acetate of ammonia.

3. What occurs when a stream of sulphuretted hydrogen gas is passed into aqueous solutions of the following substances?—ammonia, mercuric chloride, sodic arseniate, ferric chloride, potassic chromate.

4. How are the following substances prepared?—grape-sugar, alcohol, common ether, glycerine, soap.

### AGRICULTURAL CHEMISTRY.

1. What are the sources of the carbonic acid of the air? What part does it take in the growth of plants? What conditions are necessary to enable it to take that part?

2. How can it be proved that nitrification in the soil is due to the life of a microbe? In what period of the year is it most active? In what does its activity consist? How is a knowledge of the phenomena of nitrification a guide to agricultural practice?

3. Distinguish between albuminoids, amides, and amido acids. Give an

example of each. Mention the kinds of fodders in which amides are chiefly found, and explain the circumstances favourable to their production.

4. What is meant by the *nutrient ratio* of a fodder? How is it found? What is its use as a guide to feeders?

5. What is the value of the unit of ammonia in a sample of sulphate of ammonia containing 15% impurity and selling at £9 per ton?

(*Two hours allowed.*)

## NATURAL HISTORY.

### Geology.

1. Explain the proper use of the terms—*mineral rock*, *stratum*, *formation*, *horizon*.

2. Define the nature of the following sedimentary rocks—*sandstone*, *shale*, *conglomerate*, *breccia*, *oolite*, *cornstone*.

3. What ores of iron are mined in Great Britain? Give their chemical composition, and state in what geological formations they occur.

4. Contrast the flora of the Carboniferous and Jurassic periods.

### Zoology.

1. Refer a "shrew-mouse" and a "field-mouse" each to its respective mammalian order, and contrast them as to appearance, dentition, and habits.

2. Describe the differences in structure and mode of growth between the horns of an ox and of a deer.

3. What leading differences would you expect to find between the teeth of carnivorous mammalia and of those which live on herbage? Illustrate by reference to the dentition of the dog, ox, and horse.

4. Refer the "Hessian fly" to its systematic position in the class Insecta, and describe its life-history.

(*An hour and a half allowed.*)

## VETERINARY SURGERY.

1. A horse falls, deeply cutting his knees: describe what structures are injured, and what treatment should be adopted.

2. What should be the (*a*) floor surface in square feet, and (*b*) the cubic space for a stable to accommodate twelve cart-horses; and what (*c*) the maximum temperature, and (*d*) proportion of carbonic acid gas permissible in the air of such a stable when first opened in the morning?

3. Detail the conditions which produce enzootic abortion in cows, and the measures to be adopted to arrest such attacks.

4. What are the causes and appearances of navel-ill in calves, and how is it prevented?

(*An hour and a half allowed.*)

## MENSURATION AND FIELD-ENGINEERING.

NOTE.—Candidates must work out the questions on sheets of paper which will be supplied to them, which sheets must be signed by the candidates, and lodged, along with this examination paper, with the Secretary. The answers to the questions, excepting Nos. 6, 7, and 8, are also to be filled in on this paper.

### NOTE OF IMPERIAL MEASURE.

| | | | | | | |
|---|---|---|---|---|---|---|
| 10,000 | square links | = | 1 square chain. | | | |
| 625 | do. | = | 0·0625 | do. | = | 1 pole. |
| 25,000 | do. | = | 2·5 | do. | = | 40 poles = 1 rood. |
| 100,000 | do. | = | 10 | do. | = | 160 do. = 4 roods = 1 acre. |

The imperial is to the Scotch acre as 1 : 1·261 nearly.

1. Calculate the area of the enclosure A, in imperial acres, roods, and poles, and also in acres and decimals.

2. Calculate the area of the triangular enclosure A B C, and give the answer in imperial acres and decimals. Also calculate the length of the side A B to one place of decimals.

3. Four joint-purchasers buy a rectangular piece of ground 1620 links long and 650 links broad, paying respectively £75, £125, £160, and £90. How much ground should each get?

4. Calculate the area of the above figure in acres and decimals, the ordinates being 50 links apart, and the lengths of the ordinates as stated.

5. The contents of a piece of land being 359·385 imperial acres, required the area in Scotch acres and decimals.

6. Describe shortly what you would do if, when chaining a line, you met

   (1.) An obstacle which you could not see through, such as a house;

   (2.) An obstacle which you could see past but could not chain over, such as a pond.

7. Write down, as if in a level-book, the staff-readings in feet and decimals shown in the above sketch section; then reduce the levels beginning at A, so as to calculate the heights of B, C, D, and E above datum-line,—all in feet and decimals. Also give the gradient between D and E.

8. Explain shortly why the fore and back sights should be taken as nearly as possible at equal distances on each side of the instrument.

*(An hour and a half allowed.)*

## ARITHMETIC AND BOOK-KEEPING.

1. (*a*) The produce of a farm in 1892 amounted to 640 bolls, which were sold at £2, 14s. 6d. per boll; in 1893 the produce amounted to 550 bolls. At what price might these be sold to bring the same money?

   (*b*) A farmer engages 42 shearers to cut his crop of 360 acres, and in 6 days finds they have cut 54 acres. In what time would they cut down the remainder of the crop?

2. An innkeeper charged £18 for keeping 21 horses 14 days when hay was selling at 9d. per stone. What should he charge for keeping 18 horses for 42 days when hay is selling at 8d. per stone?

3. What is the value of 6 acres 3 roods 19 poles at 15s. 8½d. per rood?

4. What is the value of 60 cwt. 3 qrs. 12 lb. at £7, 13s. 6d. per cwt.?

5. If I buy hay at £4, 16s. per ton, what must I sell it at to lose 15 per cent?

6. I bought 500 sheep at £2, 2s. per head; their food cost me 5s. 6d. per head. I sold them at £2, 8s. 6d. per head. Find my whole gain, and also my gain per cent on outlay.

7. A man, his wife, and three children earn £1, 7s. 6d. a-week; the wife earns twice as much as each child, and the man three times as much as his wife. Required the man's weekly earnings.

8. Enumerate the different books which a farmer ought to keep as a record of his transactions, and show the following entries under their respective accounts in the books named:—

| | | | | £ | s. | d. |
|---|---|---|---|---|---|---|
| *Jan.* | 1. | Consign to P. Walker, to be sold by him on my account and risk, hay invoiced at | | £225 | 0 | 0 |
| " | 2. | Received cash from P. Walker on account of consignment of hay | | 100 | 0 | 0 |
| " | " | Paid into bank | | 100 | 0 | 0 |
| " | 3. | Received account sales from P. Walker, showing that the above consignment of hay realised nett | | 285 | 0 | 0 |
| " | 4. | Received in cash from P. Walker the balance of the amount realised by the sale of the hay consigned to him | | 185 | 0 | 0 |
| " | " | Paid into bank | | 185 | 0 | 0 |
| " | 5. | Received T. Jones's acceptance in payment of amount due for cattle sold to him | | 100 | 0 | 0 |
| " | 6. | Discounted T. Jones's acceptance for £100, and received in cash £99, allowed for discount £1 | | 100 | 0 | 0 |
| " | 7. | Paid F. Brook cash £98 for 2 work-horses, and was allowed discount £2 | | 100 | 0 | 0 |
| " | " | Drawn from bank | | 285 | 0 | 0 |
| " | 8. | Sent cash to J. Smith for cross-bred lambs | | 285 | 0 | 0 |
| " | 9. | Sold at public sale— | | | | |
| | | 215 lb. of wool for | £6 2 6 | | | |
| | | 5 heifers at £15, 5s. each per Macdonald, less salesman's commission, £1, 3s. 7d. | 75 1 5 | | | |
| | | | | 81 | 3 | 11 |
| " | " | Sold at public sale shorthorn bull for £21, 10s., less commission, carriage, &c., 12s. 4d. | | 20 | 17 | 8 |
| " | 10. | Paid J. Brown's account for £26, 5s., less $2\frac{1}{2}$ per cent discount for repairs at farm-steading | | | | |
| " | " | Paid to account of rent | | 256 | 0 | 0 |
| " | " | do. do. taxes | | 36 | 0 | 0 |
| " | 13. | Paid Robert Ainslie half-year's wages | | 20 | 0 | 0 |
| " | " | Handed cheque to James Grant for £10, 10s., being price of cart. | | | | |

Make the necessary entries for the following:—

A farmer previous to closing his accounts for a year observes from his bank pass-book that the bank has debited the account with £2, 7s. 6d. of accrued interest.

A farmer receives a legacy of £500, which he wishes to add to the capital already employed in the working of the farm.

Through an error in his ledger a farmer has credited stock account with £1, 17s. 6d. of discount.

Detail briefly the procedure in bringing the books named to a balance, and how the profit or loss in any one year's working would be arrived at.

(*An hour and a half allowed.*)

# VETERINARY DEPARTMENT.

The Society established a Veterinary Department in 1823, but by an arrangement made with the Royal College of Veterinary Surgeons, the Society's examination ceased in 1881. Holders of the Society's Veterinary Certificate are entitled to become Members of the Royal College of Veterinary Surgeons on payment of certain fees, without being required to undergo any further examination. The number of Students who have passed for the Society's Certificate is 1183.

In 1874, the Society resolved to vote annually eight silver medals for Class Competition to each of the two Veterinary Colleges in Edinburgh, and to the one in Glasgow.

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# FORESTRY DEPARTMENT

The Society grants First and Second Class Certificates in Forestry.

Board of Examiners.

*Science of Forestry, Practical Management of Woods, and Forest Entomology.*—Colonel Bailey, Lecturer on Forestry, Edinburgh University, 7 Drummond Place; Dr Somerville, Durham College of Science, Newcastle-on-Tyne; J. Grant Thomson, Grantown, Strathspey; D. F. Mackenzie Morton Hall, Liberton, Mid-Lothian; Andrew Slater, Haystoun, Peebles.

*Forest Botany and Zoology.*—Dr Cleghorn, Professor Bayley Balfour, Professor A. N. M'Alpine, and R. S. M'Dougall.

*Physics, Chemistry, and Meteorology.*—Dr Wm. Craig and Dr A. P. Aitken.

*Land and Timber Measuring and Surveying; Mechanics and Construction, as applied to Fencing, Drainage, Bridging, and Road-making.*—A. W. Belfrage, C.E., Edinburgh.

*Book-keeping and Accounts.*—Wm. Home Cook, C.A., Edinburgh.

Candidates must possess—1. A thorough acquaintance with the theory and practice of Forestry. 2. A general knowledge of the following branches of study, so far as these apply to Forestry: The Elements of Botany; The Elements of Physics, Chemistry, and Meteorology; Forest Entomology; Land and Timber Measuring and Surveying; Mechanics and Construction, as applied to fencing, draining, bridging, and road-making; Implements of Forestry; Book-keeping and Accounts.

The examinations are open to candidates of any age, will be both written and oral, and will include such practical tests as may from time to time be found convenient to apply.

The maximum number of marks for each subject is 100; First-Class marks in all subjects 75, Second-Class marks in all subjects 50, Pass marks in all subjects 40.

To obtain the *First-Class Certificate* a Candidate must have First-Class marks in Forestry and any three of the other subjects, and Pass in the

two remaining subjects. To obtain the *Second-Class Certificate* a Candidate must obtain Second-Class marks in Forestry and in any three of the other subjects, and Pass in the two remaining subjects.

If a Candidate fail to get First-Class marks in only one or two subjects he can, for the *First-Class Certificate*, come up again for examination in these subjects alone; otherwise he must go through the entire examination again.

The following have obtained First-Class Certificates:—

| | |
|---|---|
| George Young Wall, M.R.A.C., Durham, . . | 1870 |
| William Baillie, The Nurseries, Haddington, . | 1871 |
| William Robertson, Forester's House, Lauder, . | 1871 |
| Peter Loney, Marchmont, Duns, . . . | 1873 |
| John M. Aitken, Norwood, Lockerbie, . . . | 1880 |
| Richard Henderson, Portland Estates Office, Kilmarnock, | 1880 |
| A. H. Gibson, Kirkcaldy, . . . . | 1882 |
| Alex. Inglis, Greenlawdean, Greenlaw, . . | 1882 |
| Peter Reid, Port Ellen, Islay, . . . . | 1884 |
| John Hardie Wilson, D.Sc., F.R.S.E., St Andrews, . | 1884 |
| Cecil Henry Hooper, M.R.A.C., Highlands Farm, Swanley, Kent, . . . . . | 1886 |
| William Somerville, B.Sc., Prof. of Agriculture and Forestry, Durham College, Newcastle-on-Tyne, . | 1886 |
| John Bardgett, 1 Gayfield Street, Edinburgh, . | 1887 |
| Wilfred James Fleet, Estate Office, Thurlow, Suffolk, | 1888 |
| Arthur Charles Forbes, Bowood, Calne, Hants, . | 1888 |
| A. J. Farquharson, Newtyle, Forfarshire, . . | 1890 |
| John C. Menzies, Bankhead, Duns, . . . | 1891 |
| John F. Annand, Bruckley, Aberdeenshire, . . | 1895 |
| William Davidson, Aldbar, Brechin, . . . | 1895 |

The following have obtained Second-Class Certificates:—

| | |
|---|---|
| John M'Ewen, Yellow Cottage, Killin, . . . | 1880 |
| Thomas Berwick, 56 North Street, St Andrews, . | 1885 |
| Donald C. Cameron Grant, Southleigh, Murrayfield, . | 1886 |
| John A. Sawyer, Horningsham, Warminster, Wilts, . | 1891 |
| H. W. Tucker, Blackheath, . . . . . | 1893 |
| H. S. Daine, Woolfall Hall Farm, Huyton, Liverpool, . | 1894 |
| John Maughan, Jervaulx Abbey, Bedale, . . | 1894 |
| Eric Arthur Nobbs, Edinburgh, . . . | 1894 |
| John James Simpson, The Gardens, Wortley, near Sheffield, . . . . . . . | 1894 |
| J. W. Paterson, Brunstane Road, Portobello, . . | 1895 |
| Hugh W. Stone, Carlton Lodge, Tunbridge Wells, . | 1895 |

## SYLLABUS OF EXAMINATION.

### I.—SCIENCE OF FORESTRY AND PRACTICAL MANAGEMENT OF WOODS.

I. *Principles of Scientific Forestry.*—1. Effects of heat, light, moisture, and air-currents on forest vegetation. 2. Effects of depth, porosity,

moisture, and chemical composition of the soil on forest vegetation. 3. Effects of forest vegetation on the soil and air. 4. Rate and extent of development, longevity, and reproductive power of trees. 5. Pure and mixed woods. 6. Systems of sylviculture.

II. *Practical Management of Woods.*—7. Draining and irrigation. 8. Choice of species for various situations. 9. Seed and sowing, including nurseries. 10. Planting. 11. Natural regeneration by seed, shoots, and suckers. 12. Formation of mixed woods. 13. Tending of young woods. 14. Pruning. 15. Thinning. 16. Sylvicultural characteristics of the principal trees.

III. *Injuries by Storms and Fires.*—17. Storms. 18. Fires.

IV. *Timber.*—19. Its technical properties. 20. Its defects. 21. Recognition of different kinds of timber. 22. Processes for increasing its durability.

V. *Utilisation of Produce.*—23. Uses of wood and other produce. 24. Felling. 25. Conversion. 26. Seasoning. 27. Transport. 28. Sales. 29. Harvesting of bark.

VI. *Forest Organisation.*—30. General ideas regarding a regulated system of forest management.

*Books recommended.*—Schlich's 'Manual of Forestry'; Nisbet's 'British Forest Trees'; Nisbet's 'Studies in Forestry'; Fürst's 'Protection of Woodlands,' translated by Nisbet; Hough's 'Elements of Forestry'; Brown's 'Forester' (latest edition); Laslett's 'Timber and Timber Trees.'

## II.—FOREST BOTANY.

The fundamental facts of morphology, physiology, and classification of plants. The structure and function of the plant-cell and the plant-tissues. Their primary distribution. The secondary changes they exhibit in consequence of perennation.

The structure and function of the root and shoot in flowering-plants. Buds, their forms and uses. The flower. The fruit. The seed.

The structure and function of vegetative and reproductive organs of fungi.

Relationship of plants to air, soil, and water. Effect of light, heat, and mechanical agencies upon plants. Nutrition. The nature and elements of the food of plants. Sources of plant-food. The absorption, elaboration, transference, and storage of food. Respiration and transpiration. Parasites and saprophytes. Symbiosis.

Growth of plants in length and thickness. Correlation of growth, pruning. Germination of seeds. Formation of wood and bark. Healing of wounds.

Diseases of plants due to faulty nutrition and unfavourable circumstances of growth. Diseases due to attacks of fungi.

Natural reproduction and propagation by seeds and by buds. Fertilisation of flowers. Hybridisation. Artificial propagation by budding, grafting, layering, and cutting.

The characters of the large groups and classes of the vegetable kingdom. The characters of the families of plants which include the chief timber trees. The botanical characteristics of the principal British forest-trees

(including the structural features of their wood). The weeds of the forest and their significance.

*Books recommended.*—Scott, 'Structural Botany'; Prantl and Vines, 'Text-Book of Botany'; Marshall Ward, 'Timber and some of its Diseases'; Marshall Ward, 'Diseases of Plants'; Marshall Ward, 'The Oak'; Schlich's 'Manual of Forestry,' vol. ii., Appendix to chapter iv., by Marshall Ward; Hartig, 'Timbers, and how to know them,' translated by Somerville; Hartig, 'Anatomy and Physiology of Plants,' translated by Nisbet; Hartig, 'Diseases of Plants,' translated by Marshall Ward and Somerville; Warming, 'Handbook of Systematic Botany,' translated by Potter; Bower, 'Practical Botany for Beginners.'

## III.—FOREST ZOOLOGY.

The group Insecta: its position in the animal kingdom. Structure, mode of reproduction, and metamorphosis of insects. The outlines of classification of the group. Conditions favourable to the numerical increase of insects. Natural checks to increase (*e.g.*, birds, mammals, parasitic insects). The identification and life-history of the more important insects injurious to forest-trees and fruit-trees. The damage caused by these insect pests and their mode of attack. The damage caused by animals. Preventive and remedial measures.

*Books recommended.*—Ormerod, 'Manual of Injurious Insects'; Fürst, 'Protection of Woodlands,' translated by Nisbet; various articles in 'Transactions' of Highland and Agricultural Society and of Royal Scottish Arboricultural Society.

## IV.—PHYSICS, CHEMISTRY, AND METEOROLOGY.

### *Physics.*

Mass, weight, specific gravity, solid, liquid, and gaseous states of matter. Capillarity, osmose, vapour tension, suction pump, force pump, syphon, barometer, atmospheric pressure. Boyles's law. Levers and pulleys. Heat, measurement of heat, specific heat; transference of heat by conduction, convection, and radiation. Boiling and freezing. Latent heat. The thermometer. The conservation and transformation of energy. Light—reflection, refraction, polarisation; the spectrum. The rudiments of electricity and magnetism.

### *Chemistry.*

Elements. Oxygen, hydrogen, nitrogen;—their preparation, properties, and chief compounds. Acids, bases, salts. Combustion, oxidation, reduction. Sulphur, Carbon, Phosphorus; and their compounds, with oxygen and hydrogen. Metals—potassium, sodium, calcium, magnesium, aluminium, iron, copper, lead, mercury, and their chief compounds. Carbohydrates, marsh gas, olefiant gas, alcohol, acetic acid, oxalic acid. Distillation of wood and coal.

### *Meteorology.*

The atmosphere, its composition and physical properties. Measurement of pressure and temperature. The barometer. Rain, hail, snow, fog, cloud, dew, the dew point, hoar frost. The weathering of rocks and soils. Gases injurious to vegetation.

*Books recommended.*—'Elementary Physics,' Balfour Stewart; 'Lessons in Elementary Chemistry,' Roscoe; 'Introductory Text-Book of Meteorology,' Buchan.

## V.—LAND AND TIMBER MEASURING AND SURVEYING; MECHANICS AND CONSTRUCTION AS APPLIED TO FENCING, BRIDGING, AND ROAD-MAKING.

1. The use of the level and measuring-chain. Measuring and mapping surface areas. 2. The measurement of solid bodies—as timber, stacked bark, fagots, &c., earthwork. 3. The different modes of fencing and enclosing plantations; their relative advantages, durability, cost of construction, and repairs. 4. The setting out and formation of roads for temporary or permanent use. 5. The construction of bridges over streams and gullies; of gates or other entrances.

*Books recommended.*—'Agricultural Surveying,' by John Scott (Weale's Series); Hoppus' 'Tables'; 'Farm Roads, Fences, and Gates,' by John Scott (Weale's Series); Brown's 'Forester' (latest edition).

## VI.—BOOK-KEEPING AND ACCOUNTS.

1. Questions in Practice, Proportion, and Decimal Fractions. 2. Book-keeping—describe books to be kept; and best method of valuing timber. 3. Practical questions in Book-keeping will also be given.

*Book recommended.*—Brown's 'Forester' (latest edition).

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# EXAMINATION PAPERS, 1895.

## PRACTICAL FORESTRY.

1. What are the effects of soil-moisture on forest growth? How can moisture in the soil be best conserved for the use of trees? Which trees make greatest demand upon the water in the soil, and which least?

2. Which trees would you recommend for planting under the following circumstances? elevation—800 feet; exposure—north-east; soil—shallow and moist.

3. An area of 10 acres is to be planted, and there are 44,000 young trees available for the work. Assuming that the trees are set out in squares, what interval would separate the plants in order that the whole area might be equally stocked?

4. Describe in detail a process for impregnating timber with creosote.

5. Give a short account of the necessary arrangements preliminary to a sale of timber by auction. Draw out a satisfactory set of "conditions" for the sale.

(*Two hours allowed.*)

## FOREST BOTANY AND FOREST ENTOMOLOGY.

*Candidates are expected to answer five of the questions—three from the Section of Forest Botany, and two from the Section of Forest Entomology.*

### (*a*) Forest Botany.

1. What is a bud? Describe its structure in any tree. What kinds of bud are there? What is their destiny?

2. Give an account of the process by which a wound formed by the lopping of a branch from a deciduous tree is healed. If a large limb has to be removed from a tree, what are the points to be specially attended to if a satisfactory heal is to be secured?

3. What is meant by symbiosis? Describe and point out the significance of any symbiotic conditions known to you as occurring in forest trees.

4. What are the conditions necessary for germination of a seed? How do the conditions affect the seed in germination?

5. State the botanical characters of the oak, the elm, the ash, the chestnut, the beech, and the alder. Refer each of these trees to its natural order.

### (*b*) Forest Entomology.

6. What is meant by the phrase "metamorphosis of insects"? Illustrate by comparing the round of life of the Coleoptera (Beetles), Orthoptera (Crickets), Hemiptera (Aphides).

7. Give a short account of the life-history of *Hylobius abietis* (Pine Weevil), stating the damage it does, with preventive and remedial measures.

8. To what order of insects does *Lophyrus pini* (the Pine Sawfly) belong? How would you recognise—(*a*) the male; (*b*) the female; (*c*) the larva; (*d*) the cocoon?

(*Two hours allowed.*)

## CHEMISTRY.

1. How would you distinguish between nitrate of potash and sulphate of potash?

2. What are the beneficial effects produced by mulching?

3. In what way does humus in the soil contribute to the nourishment of trees?

4. How does bone-ash differ from bone-meal?

5. To what causes are fog on the hill-top and fog in the valley due?

6. What is meant by saying the specific heat of water is thirty times that of mercury?

7. What are the chief causes of acidity in soils? How would you prove that a soil was sour, and how would you cure its sourness?

(*An hour and a half allowed.*)

## LAND AND TIMBER MEASURING AND SURVEYING; MECHANICS AND CONSTRUCTION AS APPLIED TO FENCING, DRAINAGE, BRIDGING, AND ROAD-MAKING.

1. What is the length of the imperial chain in (1) links and (2) feet, and what is the length of a link?

2. Describe the Dumpy level, its adjustment, and its use.

3. Draw a section from imaginary levels, six sights, giving distances from start to point, and reduced levels from datum-line.

4. Calculate the cubic content of a tree of the following dimensions: length 26 feet 8 inches, diameter at one end 15 inches, and diameter at the other 18 inches, and give the result in cubic feet and decimals of a cubic foot.

5. Describe the different methods of enclosing a young hill plantation, keeping expense in view.

6. Describe the method of draining hill ground for young plantations.

7. Describe with sketch the formation of a road of a permanent kind, 12 feet wide, over mossy ground, for the purpose of removing felled timber from a plantation.

8. Draw sketch (elevation and cross section) of wooden service bridge, 30 feet span, 12 feet wide, over ravine. Assume the timber to be cut at or near the spot, and used with as little preparation as possible. Give dimensions.

*(Two hours allowed.)*

## ARITHMETIC AND BOOK-KEEPING.

1. Divide 7 by ·0035. Subtract 7·854 from $18\frac{1}{8}$. Multiply 78·54 by 1000.

2. How many deals 33 feet by 8 inches will floor a room 33 feet by 28 feet?

3. How much timber is there in a log 3 feet 8 inches by 2 feet 11 inches and $37\frac{1}{4}$ feet long?

4. A man wishes to invest £1000 in 3 per cent consols. On inquiry he finds that the price of the stock is 86 per cent. He delays making the investment until the consols have risen to 87 per cent. What effect has the delay on his income?

5. The cost price of a book is 6s. 8d., the expense of sale 5 per cent upon the cost price, and the profit 25 per cent upon the whole outlay. Find the selling price of the book.

6. Add together $\frac{1}{5}$ of a shilling, $\frac{2}{7}$ of a crown, and $\frac{4}{5}$ of a guinea, and reduce the result to the decimal of £25.

7. (*a*) Express 15 cwt. 3 qrs. 19 lb. in decimals of a ton.
   (*b*) If 72 men dig a trench 20 yards long, 1 foot 6 inches broad, and 4 feet deep, in 3 days of 10 hours each, how many men would be required to dig a trench 30 yards long, 2 feet 3 inches broad, and 5 feet deep, in 15 days of 9 hours each?

8. Describe briefly the books a Forester ought to keep, and their nature and use.

*(An hour and a half allowed.)*

# CHEMICAL DEPARTMENT.

*Chemist to the Society*—Dr A. P. AITKEN, Chemical Laboratory, 8 Clyde Street, Edinburgh.

The object of the Chemical Department is to promote the diffusion of a knowledge of Chemistry as applied to agriculture among the members of the Society, to carry out experiments for that purpose, to assist members who are engaged in making local experiments requiring the direction or services of a chemist, to direct members in regard to the use of manures and feeding-stuffs, to assist them to put the purchase of these substances under proper control, and in general to consider all matters coming under the Society's notice in connection with the Chemistry of Agriculture.

## MEMBERS' PRIVILEGES IN RESPECT OF ANALYSES.

The fees of the Chemist for analyses made for members of the Society shall, until further notice, be as follows:—

| | |
|---|---|
| The estimation of *one* ingredient in a manure or feeding-stuff, . | 5s. |
| The estimation of *two* or *more* ingredients in do. . | 10s. |

*These charges apply only to analyses made for agricultural purposes, and for the sole and private use of members of the Highland and Agricultural Society who are not engaged in the manufacture or sale of the substances analysed.*

If the sample represents a substance bought under a guarantee, and if it is found to be notably deficient, the Chemical Committee shall take cognisance of such deficiency in the same manner as they do in the case of deficient manures and feeding-stuffs supplied to members of analytical associations, provided that the Society's regulations as regards sampling are carried out, and that the seller's guarantee accompanies the sample.

Also, that valuations of manures, according to the Society's scale of units, shall be supplied in all cases in which the cash price asked by the seller accompanies the sample.

### MISCELLANEOUS.

| | | | |
|---|---|---|---|
| Analysis of water [1] to determine purity, hardness, and fitness for domestic use, . . . . . . | £1 | 0 | 0 |
| Analysis of agricultural products—hay, grain, ensilage, roots, &c., . . . . . . . . | 1 | 0 | 0 |
| Analysis of soil, to determine fertility and recommendation of manurial treatment, . . . . . | 2 | 0 | 0 |
| Search for poisons in food or viscera, . . . | 2 | 0 | 0 |

Samples should be sent (carriage paid) to Dr A. P. Aitken, 8 Clyde Street, Edinburgh.

## INSTRUCTIONS FOR SELECTING SAMPLES FOR ANALYSIS.

### MANURES.

Four or more bags should be selected for sampling. Each bag is to be emptied out separately on a clean floor, worked through with the spade, and one spadeful taken out and set aside. The four or more spadefuls thus set aside are to be mixed together until a uniform mixture is obtained. Of this mixture one spadeful is to be taken, spread on paper, and still more thoroughly mixed, any lumps which it may contain being broken

[1] Bottles for water and instructions for sampling samples are sent from the laboratory on application.

down with the hand. Of this mixture two samples of about half a pound each should be taken by the purchaser or his agent, in the presence of the seller or his agent or two witnesses (due notice having been given to the seller of the time and place of sampling), and these samples should be taken as quickly as possible, and put into bottles or tin cases to prevent loss of moisture, and having been labelled, should be sealed by the samplers—one or more samples to be retained by the purchaser, and one to be sent to the chemist for analysis.

### FEEDING-STUFFS.

Samples of feeding compounds should be taken in a similar manner.

Samples of cake should be taken by selecting three cakes, breaking each across the middle, and from the broken part breaking off a segment across the entire breadth of the cake. The three segments thus obtained should be wrapped up and sealed by the samplers, and sent for analysis as in the case of manures, and three duplicate segments similarly sealed and labelled should be retained by the purchaser.

### SOILS.

Dig a little trench about two feet deep, exposing the soil and subsoil. Cut from the side of this trench horizontal scrapings of the soil down to the top of the subsoil. Catch these on a clean board, and collect in this manner about one pound weight of soil taken from the whole surface of the section. Similar scrapings of subsoil immediately below should be taken and preserved separately. Five or six similarly drawn samples should be taken from different parts of the field, and kept separate while being sent to the chemist, that he may examine them individually before mixing in the laboratory.

### VEGETABLE PRODUCTS.

*Turnips, &c.*, 40 bulbs carefully selected as of fair average growth.

*Hay, straw, ensilage, &c.*, should be sampled from a thin section cut across the whole stack or silo, and carefully mixed about; about 2 lb. weight is required for analysis.

*Grain* should be sampled like manures.

### DAIRY PRODUCE.

*Milk.*—Samples of milk from individual cows should be taken direct from the milk-pail. Average samples from a number of cows should be taken immediately after milking. Samples to be tested for adulteration should not be drawn from the bottom or taken from the top of standing milk, but they should be ladled from the vessel after the milk has been thoroughly mixed.

For most purposes a pint-bottle of milk is a large enough sample.

*Butter and Cheese.*—About quarter-pound samples are required.

### WATERS.

When the water is from a well, it should be pumped for some minutes before taking the sample.

If the well has been standing unused for a long time, it should be pumped for some hours, so that the water may be renewed as far as possible.

If the well has been newly dug or cleaned out, it should be pumped as dry as possible, daily, for a week before taking the sample.

Water from cisterns, tanks, ponds, &c., should be sampled by immersing the bottle entirely under the water, and holding it, neck upwards, some inches below the surface. *Water from the surface should not be allowed to enter the bottle.*

Spring or stream water should not be sampled in very wet weather, but

when the water is in ordinary condition. Such waters should be sampled by immersing the bottle, if possible; but if not deep enough for that purpose, a perfectly clean cup should be used for transferring the water to the bottle.

When the bottle has been filled the stopper should be rinsed in the water before replacing it.

Interference with or disturbance of wells or springs, or the ground in their immediate vicinity, must be carefully avoided during sampling, and for at least twenty-four hours before it.

After a sample has been taken, it should be sent to the laboratory as speedily as possible.

*N.B.*—Stone jars and old wine bottles are unsuitable for conveying samples. Winchester quarts chemically cleaned should be obtained from the laboratory here.

## LOCAL ANALYTICAL ASSOCIATIONS.

With the view of encouraging, as well as regulating the conduct of, Local Analytical Associations, the Society, from 1881 to 1893, contributed from its funds towards their expenses a sum not exceeding £250 annually. In view of the passing of the Fertilisers and Feeding Stuffs Act, 1893, which places upon County Councils the duty of repressing the fraudulent sale of manures and feeding-stuffs, it was decided, at a meeting of the Directors on the 6th of December 1893, to discontinue that grant after the 1st of March 1894.

## MANURES—THEIR COMPOSITION AND CHARACTERISTICS.

**Nitrate of Soda.**—A most valuable nitrogenous manure. Perfectly soluble, and immediately available for the nourishment of the plant. Feebly retained by the soil. Rapidly goes down to the subsoil. Benefits deeply-rooting plants. *When much nitrate of soda is frequently applied and unaccompanied by other manures, the soil becomes rapidly exhausted.*

Good samples contain 95 per cent or upwards of pure nitrate of soda, equivalent to about 19 per cent of ammonia.

**Sulphate of Ammonia.**—A more concentrated nitrogenous manure than the preceding. Perfectly soluble, but not so rapid in its action as nitrate of soda. It is somewhat firmly retained by the soil, and not so liable as nitrate of soda to be washed out by heavy rains. It is therefore more suitable than nitrate for wet districts.

Good samples contain 95 per cent or more of pure sulphate of ammonia, equivalent to from about 24½ to 25 per cent of ammonia.

**Dried Blood.**—A nitrogenous manure, which differs from the above in being insoluble. It must be decomposed in the soil before it yields up its nitrogen to the plant, and this it does only slowly. The nitrogen is in the form of albumen, and is capable of yielding from 12 to 16 per cent of ammonia.

**Horn-dust—Keronikon.**—An insoluble nitrogenous manure, capable of yielding 15 to 17 per cent of ammonia. Slower than dried blood. Its efficacy as a manure increases the more finely it is ground.

Horn, when in the form of chips or coarse shavings, decomposes extremely slowly, and is not suitable for application as a manure.

**Shoddy or Wool-waste.**—An insoluble nitrogenous material used by manure manufacturers as a source of ammonia in dissolved manures. It is capable of yielding from 5 to 14 per cent of ammonia. It is a useful manure when dissolved, but not otherwise.

**Leather.**—A very insoluble nitrogenous material, yielding about 9 per cent of ammonia, used by manure manufacturers after being melted and ground, but of little value until it has been dissolved.

**Peruvian Guano.**—A general manure formed of the excrements of fish-eating birds, and containing nitrogenous compounds, phosphates, and potash.

*High-class Peruvian guano* is rich in nitrogenous matter, a large proportion of which is soluble. As formerly imported, it was capable of yielding from 8 to 12 per cent ammonia, part of which was derived from ammonia salts, and part (less than 1 per cent) from nitrates. Phosphates were low, seldom exceeding 30 per cent, but from one-quarter to one-half of the phosphates were soluble. The amount of potash was usually from 3 to 5 per cent. Not now imported.

*Low-class Peruvian guano*, as now imported, is poor in nitrogenous matter, yielding only from 3 to 5 per cent ammonia. The phosphates are correspondingly high—viz., from 30 to 50 per cent—but the proportion of soluble phosphate is much smaller than in high-class Peruvian guano. Potash occurs to a very small extent—viz., about 1 to 3 per cent.

Low-class guanos are formed originally from high-class guanos, by the washing out of soluble constituents by rain, &c., and their composition varies greatly according to the amount of washing they have undergone.

Genuine Peruvian guano frequently contains a large proportion of stony insoluble matter. It ought to be riddled before purchasing.

**Fortified Peruvian Guano,**—also called by various names, such as *improved*, *equalised*, &c.—Such guanos are mixtures, with low-class Peruvian guano for a basis. Sulphate of ammonia is added, and perhaps also other nitrogenous matter, to bring them up to the guaranteed analysis, say from 8 to 10 per cent ammonia.

**Dissolved Peruvian Guano.**—This is usually Peruvian guano dissolved in sulphuric acid, and fortified with sulphate of ammonia so as to make a strong, active manure.

**Ichaboe Guano.**—A true guano, but of recent formation. It is very rich in nitrogenous matter, which yields from 10 to 16 per cent of ammonia, but a large part of the nitrogenous matter is in the form of feathers, which are insoluble and of low manurial value, otherwise it resembles high-class Peruvian guano. The total phosphates vary from 18 to 30 per cent, of which from a fourth to a half is usually soluble. There is seldom as much as 2 per cent potash present.

**Fish Guano.**—Derived from fish-curing yards, and consisting of the heads and offal of fish, dried and ground. Properly speaking, it is not a guano. The name guano is properly applied only to the dung of birds and some other animals.

*High-class fish-guano* contains nitrogenous matter, yielding from 10 to 12 per cent of ammonia, but it is in the form of insoluble albuminous compounds, which only slowly decompose and become available as plant-food. The phosphates range from 18 to 30 per cent, and are all insoluble.

*Low-class fish-guanos* are substances like the preceding, but containing less nitrogenous matter and more phosphates. They are simply fish-bone manures, with somewhat more ammonia and less phosphate than ordinary bone-meal, and having no real resemblance to a guano.

Fish-guanos are usually impregnated with fish-oil, which detracts from the value of the manure. The oil should not exceed 3 per cent.

**Frey-Bentos Guano.**—The dried and ground residue and *debris* of animals after the extraction of "Liebig's Extract." It is not a guano. There are various grades of this manure. One contains much bone matter, another a good deal of horn. They are slow manures. The best manure is derived from muscular fibre, yielding about 14 per cent ammonia

and about 5 per cent phosphate. It is a strong nitrogenous manure, variously named.

**Bone-meal.**—Chiefly a phosphatic manure, but containing also nitrogenous matter. Phosphates range from 44 to 55 per cent, according to the purity of the bones, and are insoluble. The nitrogenous matter is capable of yielding from 4 to 5 per cent ammonia, and is also insoluble. The higher the phosphates the lower the ammonia, and *vice versa.* The finer ground it is, the more speedy is its action.

**Bone-dust.**—A coarser ground bone than the preceding.

**Crushed Bones.**—Still coarser ground.

**Steamed Bone Flour.**—Bones which have been subjected to steam at high pressure for the extraction of glue or gelatine. The residue contains from 56 to 65 per cent phosphates, and from 1 to 2 per cent ammonia. It is white-coloured and friable, and can be crushed with the hand. It is able to be, and ought to be, ground to a fine flour.

**Pure Dissolved Bones.**—Bones dissolved in sulphuric acid. It contains usually less than 20 per cent soluble phosphate, about 10 to 20 per cent of insoluble phosphate, and yields about 3½ per cent ammonia. A large proportion of the insoluble phosphate may consist of "precipitated" phosphate, which is quite as useful as soluble phosphate.

**Dissolved Bone Manures.**—These are compound manures, consisting of any mixture of phosphatic and nitrogenous materials which can be dissolved, with some admixture of bone, so as to produce a manure containing from 15 to 30 per cent soluble phosphates, and from 1 to 3 per cent ammonia. *Dissolved bone manures* frequently contain some bone material that has not been dissolved.

**Superphosphates.**—Phosphates dissolved with sulphuric acid. Their composition varies according to the richness of the phosphate from which they are made, and the extent to which they have been dissolved. If mixed with nitrate of soda, except in very small quantity, it causes loss from escape of nitrous fumes, which are injurious when breathed.

*High-class superphosphates* are made from phosphates containing a high percentage of phosphate of lime, and are very thoroughly dissolved. They should contain between 35 and 40 per cent soluble phosphate.

*Low-class superphosphates* usually contain 26 to 28 per cent soluble phosphate.

**Mineral Phosphates** exist in great variety, and contain very various proportions of phosphate of lime—viz., from 20 to 90 per cent. They are of use as manures only when they are ground to the finest flour.

**Thomas-Slag, Basic Cinder, or Slag Phosphate Meal.**—A substance obtained as a waste product in the dephosphorising of steel. It contains from 30 to 40 per cent phosphate of lime, and should be manufactured into a powder of extreme fineness, 80 per cent at least passing through No. 100 wire-cloth. It is more soluble and available for plant-food than ground mineral phosphates. It may be mixed with nitrate of soda, but *not with sulphate of ammonia,* because it contains caustic lime.

**Compound Manures.**—These are general manures containing nitrogenous matter, phosphates, and potash, and their value depends not only on the amounts of these constituents, but also on their fineness of division, their solubility, and the sources from which their ingredients are derived.

The general character of a few of the more common of these may be indicated thus:—

*Turnip Compounds.*—These usually contain from 25 to 35 per cent phosphates, of which the half or more is soluble, and nitrogenous matter, capable of yielding from 2 to 5 per cent of ammonia, and sometimes 1 or 2 per cent of potash.

*Potato Compounds.*—These are somewhat like the preceding, but contain usually less phosphate and a little more ammonia (from 4 to 8 per cent); sometimes they contain no potash, but more frequently about 3 or 4 per cent is present, and in some instances twice as much.

*Bean Compounds.*—These may contain from 10 to 20 per cent phosphates, nitrogenous matter yielding from 2 to 4 per cent of ammonia, and usually a considerable proportion of potash, often as much as from 10 to 20 per cent.

*Cereal Compounds.*—These usually contain about 20 per cent phosphates, mostly soluble, and nitrogenous matter, partly as nitrates, yielding from 3 to 8 per cent ammonia, and they may also contain potash.

*Grass Compounds.*—These are somewhat like the preceding, but may contain less phosphates and more nitrogen, part of which is usually in the form of nitrate.

## NOTES REGARDING MANURIAL CONSTITUENTS.

The three important constituents of purchased manures are phosphates, nitrogenous matter, and potash salts.

The phosphates are described in analytical reports as containing phosphoric acid equal to so much "phosphate of lime"; the nitrogenous matter as containing nitrogen equal to so much "ammonia"; the potash salts as containing so much anhydrous "potash."

1. PHOSPHATES.—The phosphates occurring in manures are known to chemists as ortho-phosphates, and they are of three kinds, which may be thus represented—

| | | |
|---|---|---|
| $\left.\begin{array}{l}\text{Lime}\\ \text{Lime}\\ \text{Lime}\end{array}\right\}$ Phosphoric acid. | $\left.\begin{array}{l}\text{Lime}\\ \text{Lime}\\ \text{Water}\end{array}\right\}$ Phosphoric acid. | $\left.\begin{array}{l}\text{Lime}\\ \text{Water}\\ \text{Water}\end{array}\right\}$ Phosphoric acid. |
| *Tricalcic phosphate.* | *Dicalcic phosphate.* | *Monocalcic phosphate.* |

*Tricalcic phosphate* is the natural phosphate occurring in bones and mineral phosphates. It is insoluble in water, and contains, when pure, about 46 per cent phosphoric acid.

*Monocalcic phosphate* is formed from tricalcic phosphate by dissolving it in acid, which takes away two-thirds of its lime, and replaces it with water. It is soluble in water, and contains, when pure, about 60 per cent phosphoric acid.

*Dicalcic phosphate* is intermediate between these two, and is formed by their union. This union occurs in the case of phosphates which have been treated with less acid than is required to dissolve them entirely—*e.g.*, in pure dissolved bones, and it is usually called *precipitated* or *reverted* phosphate. It contains, when pure, about 52 per cent phosphoric acid, is insoluble in water, but soluble in certain saline solutions, and is nearly as active manurially as monocalcic phosphate.

"Soluble phosphate" ought, strictly speaking, to mean monocalcic phosphate, but according to trade usage it does not. It means that amount of tricalcic phosphate which by means of acid has been converted into monocalcic phosphate, or in other words, the insoluble phosphate that has been rendered soluble. There is a certain advantage in expressing all kinds of phosphate in terms of their equivalent of tricalcic phosphate.

Phosphates of magnesia, of iron, and of alumina, when occurring in small proportion, are not usually estimated separately, but are reckoned as phosphate of lime.

2. NITROGEN occurs in manures mostly in three forms—Ammonia salts, nitrates, and albuminoid matter.
   Ammonia sulphate (pure), contains 25¾ per cent ammonia.
   Ammonium chloride (pure), " 31¾ " "
   Nitrate of soda (pure), contains nitrogen equal to 20 per cent ammonia.
   Albuminoid matter contains from 14 to 16 per cent nitrogen, equal to from 17 to 19 per cent ammonia, most of which sooner or later becomes available as plant-food.
3. POTASH occurs mostly in the form of soluble salts, and should be reckoned as anhydrous potash ($K_2O$).
   Sulphate of potash (pure), contains potassium = 54 per cent anhydrous potash.
   Muriate of potash (pure), contains potassium = fully 63 per cent anhydrous potash.

## FEEDING STUFFS—THEIR COMPOSITION AND CHARACTERISTICS.

These are concentrated forms of fodder, whose value depends upon their *albuminoid matter*, *oil*, and *carbohydrates* (such as starch and sugar).

LINSEED (seed of *Linum usitatissimum*, Common Flax).—Bombay seed large and pale; Baltic seed smaller and dark brown, more liable to impurities than Bombay seed; should be crushed and plotted before feeding. Useful in calf fodders, also for milk-giving, and in the last stage of masting. Quantity, 1 to 3 lb. per 1000 lb. L.W.

LINSEED-CAKE.—Much approved feeding cake; merits well known. Home-made cake usually softer and more oily than foreign. Very hard-pressed cake is low in oil, and not so easily eaten and digested. Linseed-cakes usually impure. Chief impurities, locust-beans added to give flavour and relish, rape-seed, less frequently chaff, and weed-seeds from badly screened seed. Should be broken to small pieces before feeding. Quantity, 2 to 6 lb. per 1000 lb. L.W.

RAPE-CAKE (seed of *Brassica napus* and *B. campestris*).—It has a greenish mottled appearance and a bitter taste, which renders it distasteful to cattle at first. Should be given in small quantity to begin with. Not suited for calves. When given to milch cows, the quantity should not exceed 2 or 3 lb. per head per day, or it will give a disagreeable taste to milk and butter. Sometimes very impure. A dangerous impurity is mustard-seed. May be detected by steeping in cold water for some hours, and noting smell of mustard. Danger may be avoided by steeping the ground cake in *boiling* water.

POPPY-CAKE (seed of *Papaver somniferum*).—Contains a savoury and easily digestible oil. May be fed to cattle in considerable quantity—5 to 8 lb. per head per day. More than 5 lb. per head per day to milch cows detracts from flavour of butter.

HEMP-CAKE (seed of *Cannabis sativa*).—Not much used for feeding. Not so digestible as the above, owing to abundance of woody fibre (25 per cent). Fed chiefly to horses and sheep. To milch cows not more than 1 lb. per head per day. Apt to grow mouldy in summer.

SUNFLOWER-CAKE (seed of *Helianthus annuus*).—Relished by stock, and well digested.

COTTON-CAKE (seed of *Gossypium hirsutum*, &c.). *Undecorticated*.—Best quality from Egyptian and Sea Island seed. Inferior qualities are woolly, and to be avoided. Husk has astringent properties, and is a good cure for *scour*. Should be ground to the size of linseed. Not

very digestible, owing to abundance of woody fibre (28 per cent). Should be used freshly made, because liable to mould on keeping.

*Decorticated*—viz., cotton-cake deprived of the husk.—A very concentrated and powerful bye-fodder. Should be given with caution, crushed fine, and mixed with Indian corn, oats, or other farinaceous food. Large quantity is injurious, and may even be fatal. Very variable in composition. Frequently very hard pressed, and therefore indigestible. When freshly made, softly pressed, and of good quality, it is a valuable bye-fodder. Oil very bland and digestible; used to adulterate olive-oil.

Sesame-cake (seed of *Sesamum orientale*).—Seed imported from India. Excellent bye-fodder, easily digested, much relished by all kinds of stock. Favourable for milk-giving, and also for masting. Oil bland and digestible, and much in favour for making margarine.

Rice-meal (seed of *Oryza sativa*).—The meal is a bye-product obtained in preparing rice for the market. A very good, safe, and acceptable fodder, but less concentrated than ordinary oilcakes. Varies very much in quality, and frequently adulterated with meal derived from rice husks. Much relished by stock, and useful for milch cows as well as for fattening animals.

Rye-meal.—Is the bran of rye, and rather more concentrated than wheat bran. It is very good fodder for cattle and sheep, but not for horses.

Palm-kernel Cake.—An excellent, palatable, and easily digested bye-fodder. Especially good for milch cows. Increases the proportion of fat in milk. Puts a finish upon fattening stock. When ground to powder and most of the oil extracted, it is sold as *Palm-kernel meal*, a much relished and digestible bye-fodder. A useful addition to calf-meals.

Earth-nut Cake.—The pressed seed of a leguminous plant (*Arachis hypogæa*). The most concentrated of all cakes, containing from 45 to 50 per cent albumen and 6 to 9 per cent of oil. It is very palatable and digestible. A nutritious fodder when given in moderation. Apt to be contaminated with hair, and liable to rot on keeping if badly made.

Flesh-meal.—Residue obtained in the manufacture of *Liebig's Extract of Beef*. A highly nitrogenous bye-fodder, most suitable for enriching a too farinaceous dietary, such as potatoes. Much used in that way as a swine fodder. Easily digested, and readily accepted by cattle.

Fish-meal.—Bye-product of fish-curing yards, made chiefly from the heads of cod and tusk. Resembling fish-guano in composition, but somewhat variable. Highly phosphatic, and therefore useful as a bye-fodder to young growing cattle. Ratio, from 1 to 3 lb. per head per day.

Herring-meal.—A very oily fodder, useful as an adjunct to the dietary of milch cows. Quantity, 1 to 4 lb. per head per day.

Locust-beans—*Carob Bean*.—A sugary fodder, most palatable and acceptable to all kinds of stock. Used to mix with oilcakes and meals, so as to improve their flavour.

Dried Grains.—The draff from distilleries and breweries dried so as to contain only about 10 per cent water. It is a first-class feeding-stuff if of good quality, but the qualities differ considerably.

## THE COMPOSITION OF FEEDING STUFFS.

The following is the average composition of genuine cakes and meals in common use:—

| | Albuminoids. | Oil. | Carbohydrates. |
|---|---|---|---|
| Linseed-cake . . | 29 | 11 | 32 |
| Rape-cake . . . | 31 | 10 | 30 |
| Poppy-cake . . . | 35 | 10 | 22 |
| Hemp-cake . . . | 30 | 8½ | 17 |
| Sunflower-cake . . | 33 | 9 | 27 |
| Cotton-cake . . . | 28 | 7½ | 30 |
| ,, (decorticated) | 44 | 15 | 20 |
| Sesame-cake . . | 37 | 13 | 21 |
| Rice-meal . . . | 11 | 10 | 50 |
| Paisley meal . . | 15 | 9 | 60 |
| Rye-meal . . . | 14.5 | 3½ | 60 |
| Bran . . . . | 13.5 | 3½ | 56 |
| Palm-kernel cake . . | 17 | 10 | 41 |
| Palm-kernel meal . . | 19 | 3½ | 44 |
| Earth-nut cake (shelled) | 47 | 7½ | 25 |
| Flesh-meal . . . | 71 | 13 | ... |
| Fish-meal . . . | 50 | 4 | ... |
| Herring-meal . . | 40 | 20 | ... |
| Locust-bean meal . . | 4 | 2 | 74 |
| Linseed . . . | 21 | 37 | 20 |
| Dried grains . . | 20 | 8 | 50 |

### USEFUL FACTORS.

| Amount of | Multiplied by | Gives corresponding amount of |
|---|---|---|
| Nitrogen . . . . . | 1.214 | Ammonia. |
| " . . . . . | 6.3 | Albuminoid matter. |
| Ammonia . . . . . | .824 | Nitrogen. |
| " . . . . . | 3.882 | Sulphate of ammonia. |
| " . . . . . | 3.147 | Muriate of ammonia. |
| " . . . . . | 3.706 | Nitric acid. |
| " . . . . . | 5.0 | Nitrate of soda. |
| Potash (anhydrous) . . | 1.85 | Sulphate of potash. |
| " . . . . . | 1.585 | Muriate of potash. |
| Phosphoric acid (anhydrous) . | 2.183 | [1] Phosphate of lime. |
| " " | 1.4 | Biphosphate. |
| " " | 1.648 | [2] Soluble phosphate. |
| Soluble phosphate [2] . . | 1.325 | [1] Phosphate of lime. |
| Biphosphate . . . . | 1.566 | " |
| Lime . . . . . | 1.845 | " |
| " . . . . . . | 1.786 | Carbonate of lime. |
| Chlorine . . . . | 1.648 | Chloride of sodium. |

[1] Tricalcic ortho-phosphate ($3CaO, P_2O_5$).
[2] Monocalcic ortho-phosphate ($CaO, 2H_2O, P_2O_5$).

# FORMS OF GUARANTEE.

## Guarantee of Manure.

I guarantee that the manure called.....................and sold by me to ............................................contains a minimum of—

| | | |
|---|---|---|
| *Soluble phosphoric acid* | =Phosphate of lime dissolved | ...........per cent. |
| *Insoluble phosphoric acid* | =Phosphate of lime undissolved | .........per cent. |
| *Potash salts* . . | =Potash ($K_2O$) . . . . | .... ....per cent. |
| *Total nitrogen* . . | =Ammonia . . . . | ........ per cent. |

Signature of seller........................

*Date*.................18...

## Guarantee of Feeding Stuff.

I guarantee that the feeding-stuff called...............and sold by me to ..........................................contains a minimum of—

............... per cent albuminoids.
............... per cent oil.
............... per cent carbohydrates.

Signature of seller........................

*Date*.................18...

# UNITS TO BE USED IN DETERMINING THE COMMERCIAL VALUE OF MANURES.[1]

*Terms*—CASH, including Bags gross weight—not including Carriage.

*N.B.*—These units are based on the present RETAIL PRICES at port. When these units are multiplied by the percentages in the analysis of a Manure, they will produce a value representing very nearly the cash price at which one SINGLE TON may be bought in fine sowable condition. Larger purchases may be made on more favourable terms.

For Season 1895.

| | Guanos. | | Scrap Manures. | | | Bone Manures. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Items to be Valued. | Ichaboe. | Peruvian (Riddled). | Fish Guano. | Frey-Bentos Guano. | | Bone-Meal. | | Steamed Bone Flour. | Dissolved or Vitriolated Bones. | Superphosphates. |
| Classes | Genuine. | Genuine | | *a.* | *b.* | *a.* | *b.* | | | |
| Phosphates— | | | | | | | | | | |
| Dissolved . . | .. | .. | .. | .. | .. | .. | .. | .. | 3/- | 1/11 |
| Undissolved . . | 2/3 | 2/3 | 1/4 | 1/6 | 1/4 | 1/2 | 1/- | 1/4 | 1/6 | .. |
| Nitrogen . . . | 21/- | 21/3 | 13/6 | 15/6 | 13/6 | 11/- | 10/0 | 12/- | 14/- | .. |
| or Ammonia . . | 17/3 | 17/3 | 11/1 | 12/9 | 11/1 | 9/- | 8/3 | 9/10 | 11/6 | .. |
| Potash . . . | .. | 3/6 | .. | .. | .. | .. | .. | .. | .. | .. |
| Prices per ton, March 1895, From | 250/- | 200/- | 105/- | 150/- | 120/- | 105/- | 100/- | 105/- | 105/- | 25°/。=48/- |
| to | 270/- | 280/- | 140/- | 190/- | 140/- | 110/- | 105/- | 110/- | 120/- | 30°/。=69/- |

[1] See note, p. 40.

## CASH PRICES (MARCH).

| MANURES | Guarantee. | Price per Ton. | Unit. |
|---|---|---|---|
| | Per cent. | £ s d. | |
| Sulphate of ammonia, 97 per cent | 19½ N. | 11 10 0 | N. =11/9 |
| Nitrate of soda, 95 per cent | 15½ " | 8 15 0 | " =11/7 |
| Castor-cake dust | 4.5 " | 3 5 0 | " =14/6 |
| Dried blood | 14 " | 9 0 0 | " =13/0 |
| Muriate of potash, 80 per cent | 50 Pot. | 8 0 0 | Pot. = 3/8 |
| Sulphate of potash, 50 per cent | 27 " | 4 15 0 | " = 3/6 |
| Kainit | 12 " | 2 0 0 | " = 3/4 |
| Nitrate of potash, 78 per cent | 11 N.<br>40 Pot. | 15 0 0 | N. =14/<br>Pot. = 3/9 |
| Ground Charleston phos. | 57 Phos. | 2 10 0 | Phos.=0/11 |
| Belgian phosphate | 40 " | 1 15 0 | " = 0/11 |
| Algerian phosphate | 64 " | 2 12 6 | " = 0/8 |
| Thomas-slag phosphate | 37 " | 2 5 0 | " = 1/3 |
| Albert's "soluble" basic powder | 23 " | 2 0 0 | " = 1/5 |
| Phosphatic guano | 67 "<br>1 N. | 6 0 0 | " = 1/6<br>N. =13/ |

| FEEDING STUFFS. | Analyses. | | | Price per Ton in bags. |
|---|---|---|---|---|
| | Album. | Oil. | Carbo-hydrates. | £ s d. |
| Linseed-cake | 28 | 10 | 35 | 6 10 0 |
| " Canadian | 28 | 10 | 35 | 5 14 0 |
| Decorticated cotton-cake | 45 | 10 | 20 | 5 5 0 |
| Undecorticated do. | 42 | 7 | 25 | 3 17 6 |
| Rape-cake | 32 | 10 | 27 | 4 15 0 |
| Bean-meal | 25 | 2 | 50 | 5 15 0 |
| Locust-bean meal | 6 | 2 | 70 | 4 10 0 |
| Dried grains | 20 | 8 | 50 | 3 15 0 |
| Indian corn | 10 | 5 | 55 | 5 2 6 |
| Paisley meal | 15 | 9 | 60 | 3 7 6 |
| Linseed (whole) | 20 | 35 | 14 | 11 0 0 |
| Linseed-oil | .. | .. | .. | 20 0 0 |
| Molasses | .. | .. | .. | 3 5 0 |

## CLASSIFICATION OF MANURES.

| | |
|---|---|
| Fish guano . . . | Finely ground, and containing not more than 3 per cent oil. |
| Frey-Bentos guano . | (a) Meat-meal, free from horn, yielding over 11 per cent nitrogen. (b) Mixed scrap, yielding 6 to 7 per cent nitrogen, and 30 to 40 per cent phosphates. |
| Bone-meal . . . | (a) 90 per cent passing ½-inch sieve. (b) Coarser. Genuine bone-meal contains from 45 per cent to 55 per cent phosphates, and from 3½ per cent to 4½ per cent nitrogen. The better qualities contain little or no fat. |
| Steamed bone-flour . | Ground to flour and containing about 60 per cent phosphates, and about 2 per cent nitrogen. |
| Dissolved bones . . | Must be pure—*i.e.*, containing nothing but natural bones and sulphuric acid. |
| Mixtures . . . | To be valued according to the unit values (as given above) of the ingredients of which they are guaranteed *and also found* to be composed, with an addition of from 5 to 10 per cent according to the fineness of their manufacture. |
| Thomas-slag and ground phosphates | Fineness of grinding is of paramount importance. The coarsest kind used should be so finely ground that 80 per cent passes through a sieve of 10,000 holes per sq. inch. |

## INSTRUCTIONS FOR VALUING MANURES.

The commercial values of manures are determined by means of the Units in the following manner:—

Take the analysis of the manure, and look for the following substances:—

| | |
|---|---|
| Phosphates dissolved (or soluble phosphate) | No other items but these are to be valued. |
| „ undissolved (or insoluble „ ) | |
| Nitrogen . . . . . . . . | |
| Potash . . . . . . . . . | |

*Should the analysis or the guarantee not be expressed in that way, the chemist or the seller should be asked to state the quantities in these terms.*

Suppose the manure is bone-meal:—

There are two classes of bones, according to their fineness. An ordinary bone-meal will fall under Class (*a*), and it will contain about 50 per cent phosphate, and 4½ per cent nitrogen. The units for bones, Class (*a*), are 1s. 2d. for insoluble phosphate, and 11s. for nitrogen. Therefore the value is—

| | | | | | | |
|---|---|---|---|---|---|---|
| Insol. phosphate, | 50 times 1s. 2d., | equal to | £2 | 18 | 4 | |
| Nitrogen, | 4 „ 11s. | „ | 2 | 4 | 0 | |
| | | Say | £5 | 2 | 0 | per ton. |

Suppose the manure is dissolved or vitriolated bones:—

It must be guaranteed "pure."

The units in the Schedule are 3s. for soluble phosphate, 1s. 6d. for insoluble phosphate, and 14s. for nitrogen.

The analysis will be about 15 per cent soluble phosphate, 20 per cent insoluble phosphate, and 2½ per cent nitrogen. In that case the value would be—

| | | | | | | |
|---|---|---|---|---|---|---|
| Sol. phosphate, | 15 times 3s., | equal to | £2 | 5 | 0 | |
| Insol. „ | 20 „ 1s. 6d. | „ | 1 | 10 | 0 | |
| Nitrogen, | 2½ „ 14s. | „ | 1 | 15 | 0 | |
| | | Say | £5 | 10 | 0 | per ton. |

Suppose the manure is a superphosphate,—say an ordinary superphosphate, with 27 per cent soluble phosphate and 3 per cent insoluble phosphate. It is valued thus—

Sol. phosphate, 27 times 1s. 11d., equal to, say, £2, 12s. per ton.
*Insoluble phosphate is not valued in a superphosphate.*

*Note.*—The units have reference solely to the COMMERCIAL VALUES of Manures, and not to their AGRICULTURAL VALUES.

*Thus, in stating soluble phosphate in dissolved bones at* 3s. *per unit, and that in superphosphate at* 1s. 11d., *it is meant that these are the prices per unit at which soluble phosphate can be bought in these two manures; but it does not mean that the soluble phosphate in the one is* 1s. 1d. *per unit better as a manure than that in the other. It is probably no better.*

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# BOTANICAL DEPARTMENT.

*Consulting Botanist to the Society*—A. N. M'ALPINE,
60 John Street, Glasgow.

The Society have fixed the following rates of charge for the examination of plants and seeds for the *bona fide* and individual use and information of members of the Society (not being seedsmen), who are particularly requested, when applying to the Consulting Botanist, to mention the kind of examination they require, and to quote its number in the subjoined schedule. The charge for examination must be paid at the time of application, and the carriage of all parcels must be prepaid.

*Scale of Charges.*

1. A report on the purity, amount, and nature of foreign materials, 2s.
2. On the germinating power of a sample of seed, 2s.
3. Determination of the species of any weed or other plant, or of any vegetable parasite, with a report on its habits and the means for its extermination or prevention, 5s.
4. Report on any disease affecting farm crops, 5s.
5. Determination of the species of any natural grass or fodder plant, with a report on its habits and pasture or feeding value, 1s.

The Consulting Botanist's Reports are furnished to enable members—purchasers of seeds and corn for agricultural purposes—to test the value of what they buy, and are not to be used or made available for advertising or trade purposes by seedsmen or otherwise.

*Instructions for Selecting and Sending Samples.*

In sending seed or corn for examination, the utmost care must be taken to secure a fair and honest sample. In the case of grass seeds, the sample would be drawn from the centre of the sack or bag, and in all cases from the bulk delivered to the purchaser. If anything supposed to be injurious or useless exists in the corn or seed selected, samples should also be sent.

When possible, at least one ounce of grass and other small seeds should be sent, and two ounces of cereals or larger seeds. The exact name under which the seed has been bought (but preferably, a copy of the invoice) should accompany the sample.

Grass seeds should be sent at least four weeks, and clover seeds three weeks, before they are to be used.

In collecting specimens of plants, the whole plant should be taken up and the earth shaken from the roots. If possible, the plants must be in flower or fruit. They should be packed in a light box, or in a firm paper parcel.

Specimens of diseased plants or of parasites should be forwarded as fresh as possible. Place them in a bottle, or pack them in tinfoil or oil-silk.

All specimens should be accompanied with a letter specifying the nature of the information required, and stating any local circumstances (soil, situation, &c.) which, in the opinion of the sender, would be likely to throw light on the inquiry.

It is strongly recommended that members purchasing seeds should insist—

(1) Upon having from the seller a guarantee stating the purity and germination of the seed supplied.

(2) That the bulk be same as sample.

(3) That it contain not more than 5 per cent other than the species ordered.

If the purity and germination of the seed is not known, it is impossible to tell either its money value or the proper amount to be sown.

It is also strongly recommended that the purchase of prepared mixtures should be avoided, and the different seeds to be used should be purchased separately.

Parcels or letters containing seeds or plants for examination (carriage or postage paid) must be addressed to Professor M'Alpine, Botanical Laboratory, 60 John Street, Glasgow.

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# DAIRY DEPARTMENT.

The Society established in 1885 a Dairy Department, to promote the dairy interests.

During 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, and 1894, the Society placed at the disposal of the Committee a sum of £100 to aid local efforts in providing Technical Education in Dairying.

In the years stated below the grants have been allocated as follows :—

| Branch. | 1890. | 1891. | 1892. | 1894. |
|---|---|---|---|---|
| Royal Northern Society . . | ... | £20 0 0 | £20 0 0 | . |
| Angus and Mearns Dairy School | ... | 20 0 0 | 20 0 0 | £20 0 0 |
| Scottish Dairy Institute, Kilmarnock . . . | £100 0 0 | 60 0 0 | 60 0 0 | 60 0 0 |
| | £100 0 0 | £100 0 0 | £100 0 0 | £80 0 0 |

# PREMIUMS.

## GENERAL REGULATIONS FOR COMPETITORS.

1. It is to be distinctly understood that the Society is not responsible for the views, statements, or opinions of any of the writers whose papers are published in the 'Transactions.'

2. All reports must be legibly written, and on one side of the paper only; they must specify the number and subject of the Premium for which they are in competition; they must bear a distinguishing motto, and be accompanied by a sealed letter, similarly marked, containing the name and address of the reporter—initials must not be used.

3. No sealed letter, unless belonging to a report found entitled to at least one-half of the Premium offered, will be opened without the author's consent.

4. Reports for which a Premium, or not less than one-half of it, has been awarded, become the property of the Society, and cannot be published in whole or in part, nor circulated in any manner without the consent of the Directors. All other papers will be returned to the authors if applied for within twelve months.

5. The Society is not bound to award the whole or any part of a Premium.

6. All reports must be of a practical character, containing the results of the writer's own observation or experiment, and the special conditions attached to each Premium must be strictly fulfilled. General essays, and papers compiled from books, will not be rewarded or accepted. Weights and measurements must be indicated by the imperial standards.

7. The Directors, before or after awarding a Premium, shall have power to require the writer of any report to verify the statements made in it.

8. The decisions of the Board of Directors are final and conclusive as to all matters relating to Premiums, whether for Reports or at General or District Shows, and it shall not be competent to raise any question or appeal touching such decisions before any other tribunal.

9. The Directors will welcome papers from any Contributor on any suitable subject not included in the Premium List; and if the topic and the treatment of it are both approved, the writer may be remunerated, and his paper published.

# CLASS I.

# REPORTS.

## Section 1.—THE SCIENCE AND PRACTICE OF AGRICULTURE.

### FOR APPROVED REPORTS.

1. On the results of experiments for fixing and retaining the volatile and soluble ingredients in Farmyard Manure—Twenty Sovereigns. To be lodged by 1st November in any year.

The Report must detail the treatment adopted to fix and retain these ingredients—the materials used for that purpose, and the quantity and cost thereof—comparative analyses of the manure with and without the treatment, and also a statement of the crops grown with manure and without such treatment, must be given by the Reporter. The experiments to have extended over at least two years and crops.

2. On experiments for ascertaining the actual addition of weight to growing or fattening Stock, by the use of different kinds of food—Twenty Sovereigns. To be lodged by 1st November in any year.

The attention of the experimenter is directed to turnips, carrots, beet, mangel-wurzel, potatoes, cabbage, as well as to beans, oats, barley, wheat, Indian corn, linseed, oilcake or rape-cake, and to the effect of warmth and proper ventilation, and the difference between food cooked and raw. The above roots and other kinds of food are merely suggested; competitors are neither restricted to them nor obliged to experiment on all of them.

When experiments are made with linseed and cake, attention should be paid to the comparative advantages, economically and otherwise, of the substance in these two states.

Before commencing the comparative experiments, the animals must be fed alike for some time previously.

The progress of different breeds may be compared. This will form an interesting experiment of itself, for Reports of which encouragement will be given.

*N.B.*—The experiments specified in the two previous subjects must be conducted over a period of not less than three months. No lot shall consist of fewer than four Cattle or ten Sheep. The animals selected should be of the same age, sex, and breed, and as nearly as possible of the same weight, condition, and maturity. The live weight before and after the experiment must be stated, and if killed, their dead weight and quantity of tallow.

3. On any useful practice in Rural Economy adopted in other countries, and susceptible of being introduced with advantage into Scotland—The Gold Medal. To be lodged by 1st November in any year.

The purposes chiefly contemplated by the offer of this premium is to induce travellers to notice and record such particular practices as may seem calculated to benefit Scotland. The Report to be founded on personal observation.

## Section 2.—ESTATE IMPROVEMENTS.

### FOR APPROVED REPORTS.

1. By the Proprietor in Scotland who shall have executed the most judicious, successful, and extensive Improvement—The Gold Medal, or Ten Sovereigns. To be lodged by 1st November in any year.

Should the successful Report be written for the Proprietor by his resident factor or farm manager, a Minor Gold Medal will be awarded to the writer in addition to the Gold Medal to the Proprietor.

The merits of the Report will not be determined so much by the mere extent of the improvements, as by their character and relation to the size of the property. The improvements may comprise reclaiming, draining, enclosing, planting, road-making, building, and all other operations proper to landed estates. The period within which the operations may have been conducted is not limited, except that it must not exceed the term of the Reporter's proprietorship.

2. By the Proprietor or Tenant in Scotland who shall have reclaimed within the ten preceding years not less than forty acres of Waste Land—The Gold Medal, or Ten Sovereigns. To be lodged by 1st November in any year.

3. By the Tenant in Scotland who shall have reclaimed within the ten preceding years not less than twenty acres of Waste Land —The Gold Medal, or Ten Sovereigns. To be lodged by 1st November in any year.

4. By the Tenant in Scotland who shall have reclaimed not less than ten acres within a similar period—The Medium Gold Medal, or Five Sovereigns. To be lodged by 1st November in any year.

The Reports in competition for Nos 3, 4, and 5 may comprehend such general observations on the improvement of waste lands as the writer's experience may lead him to make, but must refer especially to the lands reclaimed—to the nature of the soil—the previous state and probable value of the subject—the obstacles opposed to its improvement—the details of the various operations—the mode of cultivation adopted—and the produce and value of the crops produced. As the required extent cannot be made up of different patches of land, the improvement must have relation to one subject; it must be of profitable character, and a rotation of crops must have been concluded before the date of the Report. *A detailed statement of the expenditure and return* and a certified measurement of the ground are requisite.

5. By the Proprietor or Tenant in Scotland who shall have improved within the ten preceding years the Pasturage of not less than thirty acres, by means of top-dressing, draining, or otherwise, without tillage, in situations where tillage may be inexpedient—The Gold Medal, or Ten Sovereigns. To be lodged by 1st November in any year.

6. By the Tenant in Scotland who shall have improved not less than ten acres within a similar period—The Minor Gold Medal. To be lodged by 1st November in any year.

Reports in competition for Nos. 5 and 6 must state the particular mode of management adopted, the substances applied, the elevation and nature of the soil, its previous natural products, and the changes produced.

## SECTION 3.—HIGHLAND INDUSTRIES AND FISHERIES.

### FOR APPROVED REPORTS.

1. The best mode of treating native Wool; cleaning, carding, dyeing, spinning, knitting, and weaving by hand in the Highlands and Islands of Scotland—Five Sovereigns. To be lodged by 1st November 1895.

## SECTION 4.—MACHINERY.

### FOR APPROVED REPORTS.

## SECTION 5.—FORESTRY DEPARTMENT.

### FOR APPROVED REPORTS.

1. On Plantations of not less than eight years' standing formed on deep peat-bog—The Medium Gold Medal, or Five Sovereigns. To be lodged by 1st November 1895.

The premium is strictly applicable to deep peat or flow moss; the condition of the moss previous to planting, as well as at the date of the Report, should, if possible, be stated.

The Report must describe the mode and extent of the drainage, and the effect it has had in subsiding the moss—the trenching, levelling, or other preliminary operations that may have been performed on the surface—the mode of planting—kinds, sizes, and number of trees planted per acre—and their relative progress and value, as compared with plantations of a similar age and description grown on other soils in the vicinity.

2. On the Life-History of any Insect or Tribe of Insects which is injurious to British Forest Trees (*e.g.*, *Scolytus destructor*, of the Elm)—Fifteen Sovereigns. To be lodged by 1st November 1895.

The means for guarding against or destroying these pests to be mentioned, and the Report to be illustrated by original drawings and specimens of the insect and its ravages.

The *Pine Beetle*, the *Fir Weevil*, the *Black Arch Nun* (or *Spruce Moth*), and the *Elm-bark Beetle* are excluded, having been already reported on.

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## CLASS II.

## DISTRICT COMPETITIONS.

### Regulations 1895.

*The Money Premiums and Medals awarded at District Competitions will be sent direct to the winners in January next. No payments must therefore be made by the Secretary or Treasurer of any local Association.*

*Grants in aid of* District Competitions *for* 1896 *must be applied for before* 1*st November* 1895, *on Forms to be obtained from the Secretary.*

*When a Grant has expired, the District cannot apply again for aid for two years.*

### Section I.—GRANTS TO DISTRICT SOCIETIES FOR HORSES, CATTLE, SHEEP, AND PIGS.

1. Class of Stock—Limit of Grants, £340.—The Highland and Agricultural Society will make Grants to District Societies to deal with, as in the opinion of the District Societies the need of each district may require, for such classes of breeding Stock of Horses, Cattle, Sheep, and Pigs as are embraced in the General Show Prize List of the Highland and Agricultural Society. The total sum to be expended by the Highland and Agricultural Society in such Grants shall not exceed the sum of £340 in any one year.

2. Grant to District, £12.—The portion of the Grant to any one District Society shall not exceed the sum of £12 in any one year.

3. Continuance of Grant Three Years—Advertising.—The Grant shall continue for three alternate years, provided always that the District Society shall, in the two intermediate years, continue the competition by offering Premiums equal in amount to not less than one-half the sum given by the Highland and Agricultural Society, and for the same class of Stock as that selected in each previous year to compete for the Highland and Agricultural Society's Prizes. The Prizes when given by the Highland and Agricultural Society must be announced as the Society's gift. If no competition takes place for two years the Grant expires.

4. When it is agreed to hold the General Show of the Society in any district, no provincial show shall be held in that district in the months of June, July, or August.

5. Medals.—In the two alternate years the Highland and Agricultural Society will place three Minor Silver Medals at the disposal of the District Societies, for the same classes of Stock as those for which the Money Premiums are offered, provided that not less than three lots are exhibited in the same class.

6. Rules of Competition.—The Rules of Competition for the Premiums, the Funds for which are derived from Grants of the Highland and

Agricultural Society, shall be such as are generally enforced by the Society receiving the Grant for Premiums offered by itself.

7. AREA AND PARISHES—FIVE PARISHES.—When making application for Grants from the Highland and Agricultural Society, the District Society must delineate the area and the number of parishes comprised in the district, and *except in special cases*, no District Society shall be entitled to a Grant whose show is not open to at least *five* Parishes.

8. NOMINATION OF MEMBERS.—The Directors may nominate one or more members of the Highland and Agricultural Society resident in the district, whose duty it shall be to see that the conditions imposed by the Board are complied with.

9. REPORTS.—Blank Reports will be furnished to the Secretaries of the different District Societies. These Reports must in all details be completed and lodged with the Secretary of the Highland and Agricultural Society on or before the 1st of November next following the competition, both in the years when the Grant is given and in the two intermediate years, for the approval of the Directors of the Highland and Agricultural Society, against whose decision there shall be no appeal. All such Reports must be signed and certified by the Members of the Highland and Agricultural Society nominated under Rule 8.

10. GRANTS—WHEN PAID.—The Grants made to District Societies will be paid in the January following the competition, by Precepts issued by the Directors of the Highland and Agricultural Society to the winners of the prizes. No payments of these Grants must be made by the Secretary or Treasurer of any District Society. Medals will be issued at the same time.

11. RENEWAL OF APPLICATION.—No application for renewal of a Grant to a District Society will be entertained until the expiration of *two years* from the termination of the last Grant.

12. DISPOSAL OF APPLICATIONS.—In disposing of applications for District Grants, the Directors of the Highland and Agricultural Society shall keep in view the length of interval that has elapsed since the expiration of the last Grant, giving priority to those District Societies which have been longest off the list.

13. DAIRY PRODUCE.—Upon application being made by District Societies, a limited number of Medals will be placed at the disposal of District Societies for Dairy Produce.

## DISTRICTS.

1. SPEY, AVEN, AND FIDDOCHSIDE.—*Convener*, Sir George Macpherson-Grant of Ballindalloch, Bart.; *Secretary*, A. R. Stuart of Inverfiddich, Craigellachie. Granted 1891.
2. JED-FOREST.—*Convener*, Gideon Pott, Knowesouth, Jedburgh; *Secretary*, Richard Davidson, Swinnie, Jedburgh. Granted 1891.
3. CENTRAL BANFFSHIRE.—*Convener*, John M'Pherson, Mulben, Keith; *Secretary*, George Donald, Ladyhill, Grange, Keith. Granted 1893.
4. STRATHSPEY.—*Convener*, John Smith, Inverallan House, Grantown; *Secretary*, D. G. Lawson, Auchnagallen, Grantown. Granted 1893.
5. WEST LINTON.—*Convener*, George Forrest, Edston, Peebles; *Secretary*, F. W. Dyson, Crossburn, Peebles. Granted 1893.
6. ISLAY, JURA, AND COLONSAY.—*Convener*, ; *Secretary*, Robert Cullen, Bridgend, Islay. Granted 1893.
7. WEST TEVIOTDALE.—*Convener and Secretary*, James Oliver, Thornwood, Hawick. Granted 1893.

8. Kincardineshire.—*Convener*, John Hart, Cowie Mains, Stonehaven; *Secretary*, A. B. Annandale, Stonehaven. Granted 1892. (In abeyance in 1894.)
9. Aberdour.—*Convener*, Alex. Lovie, Nether Boyndlie, Fraserburgh; *Secretary*, William Chapman, Woodhead, Aberdour. Granted 1895.
10. Vale of Alford.—*Convener*, George Wilken, Waterside of Forbes, Alford, N.B.; *Secretary*, John Reid, Cairnballoch, Alford, N.B. Granted 1895.
11. Caithness.—*Convener*, A. W. Henderson of Bilbster, Wick; *Secretaries*, Paterson Smith, Wick, and George Brown, Watten Mains, Wick. Granted 1895.
12. Dalkeith.—*Convener*, William Park, Brunstane, Portobello; *Secretary*, John Dobbie, Campend, Dalkeith. Granted 1895.
13. Black Isle.—*Convener*, James F. Mackenzie of Allangrange, Munlochy; *Secretary*, Thomas Henderson, Fortrose. Granted 1895.
14. Argyll.—*Convener*, J. Campbell of Kilberry, Tarbert; *Secretary*, Duncan M'Laren, Union Bank, Tarbert. Granted 1894.
15. Carrick.—*Convener*, Alexander Cross of Knockdon, 19 Hope Street, Glasgow; *Secretary*, David Brown, Banker, Maybole. Granted 1894.
16. Morayshire.—*Convener*, James Brander, Pittendreich, Elgin; *Secretary*, James Black of Sheriffston, Elgin. Granted 1894.
17. Kinglassie.—*Convener and Secretary*, James Inglis, Redhouse, Cardenden. Granted 1894.
18. Forth.—*Convener and Secretary*, Thomas Nimmo, Lawhead, Forth, Lanark. Granted 1894.
19. Weem.—*Convener*, Robert Menzies, Tirinie, Aberfeldy; *Secretary*, . Granted 1894.

In 1895.

Nos. 1 and 2 are in competition for the last year.
Nos. 3, 4, 5, 6, 7, and 8 are in competition for the second year.
Nos. 9, 10, 11, 12, and 13 are in competition for the first year.
Nos. 14, 15, 16, 17, 18, and 19 compete for local Premiums.

## Section 2.—GRANTS TO HORSE ASSOCIATIONS, &c., FOR STALLIONS FOR AGRICULTURAL PURPOSES.

1. Horses—Limit of Grant, £210.—The Highland and Agricultural Society will make Grants to Horse Associations and other Societies in different districts engaging Stallions for agricultural purposes. The total sum expended by the Highland and Agricultural Society in such Grants shall not exceed the sum of £210 in any one year.

2. Grant to each, £15.—The portion of the Grant to any one Horse Association, &c., shall not exceed the sum of £15 in any one year.

3. Continuance of Grant Three Years—Intermediate Year.—The Grant shall continue for three alternate years, provided always that the Horse Association or Society shall, in the two intermediate years, offer at least a sum equal in amount to that granted by the Highland and Agricultural Society for the hire of a Horse in connection with the Association or Society to whom the Grant is made.

4. Nomination of Members.—The Directors of the Highland and Agricultural Society shall nominate one or more members of the Highland and Agricultural Society, resident in the Districts in which the Society benefited is located, whose duty it shall be to see that the conditions imposed by the Board are complied with.

5. Reports—Penalty for not engaging Horse.—No Grant by the Highland and Agricultural Society to Horse Associations, &c., will be paid unless a report, signed and certified by the members appointed under Rule 4, be furnished to the Highland and Agricultural Society not later than the 1st of November in each year in which the Grant is made, and also in the alternate years, stating that a Horse has been engaged by the Horse Association or other Society to whom the Grant is made; and in the event of a Horse not being engaged in any one year while the provisions of the Grant are in force, the Grant made by the Highland and Agricultural Society will cease.

6. Rules 10 (Time of Payment), 11 (Renewal of Grant), and 12 (Disposal of Applications) applicable to Section 1, shall be applicable to Section 2.

## DISTRICTS.

1. Nairnshire.—*Convener*, R. Anderson of Lochdhu, Nairn; *Secretary*, John Joss, Budgate, Cawdor, Nairn. Granted 1891.
2. Inverness Farmers' Society.—*Convener*, Duncan Forbes of Culloden, Inverness; *Secretary*, William M'Bean, Cradlehall, Inverness. Granted 1893.
3. Speyside Clydesdale Horse-Breeding Association.—*Convener*, Col. John Gordon Smith of Delnabo, Glenlivet, Ballindalloch; *Secretary*, A. R. Stuart of Inverfiddich, Craigellachie. Granted 1893.
4. Lower Ward of Renfrewshire Stallion Society. — *Convener*, R. Sinclair Scott, Burnside, Largs; *Secretary*, R. Stewart Walker, 12 William Street, Greenock. Granted 1893.
5. Turriff Clydesdale Horse Society.—*Convener*, Sir R. Abercromby, Bart., Forglen House, Turriff; *Secretary*, R. Cruickshank, Claymires, Turriff. Granted 1895.
6. Kelso District Clydesdale Horse Society. — *Convener*, W. G. Hogarth, Linton Bankhead, Kelso; *Secretary*, Adam Liddell, 3 Square, Kelso. Granted 1895.
7. Lauderdale.—*Convener*, R. Dickinson, Longcroft, Lauder; *Secretary*, George L. Broomfield, Lauder. Granted 1894.
8. Northern District of Kincardineshire Horse Society.—*Convener and Secretary*, John Hart, Mains of Cowie, Stonehaven. Granted 1894.
9. Orkney Horse-Breeding Society.—*Convener*, James Drever, Swannay, Finstown, Orkney; *Secretary*, Robert Scarth, Binscarth, Finstown, Orkney. Granted 1894.
10. Strathearn Central. — *Convener and Secretary*, Robert Gardiner, Henhill, Forteviot. Granted 1894.

### In 1895.

No. 1 is in competition for the last year.
Nos. 2, 3, and 4 are in competition for the second year.
Nos. 5 and 6 are in competition for the first year.
Nos. 7, 8, 9, and 10 compete for local premiums.

## DAIRY PRODUCE.

Upon application being made by District Societies, a limited number of Medals will be placed at the disposal of District Societies for Dairy Produce.

## SPECIAL GRANTS.

£20 to the Ayrshire Agricultural Association, to be competed for at the Dairy Produce Show at Kilmarnock.—*Convener*, The Hon. G. R. Vernon, Auchans House, Kilmarnock; *Secretary*, James M'Murtrie, Ayr. Granted 1872.

£5 to Shetland Agricultural Society.—*Convener*, John Bruce of Sumburgh, Lerwick; *Secretary*, Archibald J. Garrioch, Lerwick. Granted 1893.

£3 to Orkney.—*Secretary*, James Johnston, Orphir House, Orkney. Granted 1883.

£3 to South Uist and Barra.—*Convener and Secretary*, Donald Paterson, Askernish, South Uist, Oban. Granted 1890. (In abeyance in 1892, 1893, and 1894.)

£3 to North Uist.—*Convener*, Sir John Campbell Orde, Bart.; *Secretary*, James M. Fraser, Banker, Lochmaddy. Granted 1890. (In abeyance in 1894.)

## MEDALS IN AID OF PREMIUMS GIVEN BY LOCAL SOCIETIES.

The Society, being anxious to co-operate with local Associations, will give a limited number of Minor Silver Medals annually to Societies, not on the list of Cattle, Horse, or Sheep Premiums, in addition to the Money Premiums awarded in the Districts for—

1. Best Bull, Cow, Heifer of any pure breed, or Ox.
2. Best Stallion, Mare, or Gelding.
3. Best Tup, or Pen of Ewes or Wethers.
4. Best Boar, Sow, or Pig.
5. Best Pens of Poultry.
6. Best Sample of any variety of Wool.
7. Best Sample of any variety of Seeds.
8. Best managed Farm.
9. Best managed Green Crop.
10. Best managed Hay Crop.
11. Best managed Dairy.
12. Best Sweet-Milk Cheese.
13. Best Cured Butter.
14. Best sample of Honey, not less than 5 lb., taken without destroying the bees.
15. Best collection of Roots.
16. Best kept Fences.
17. Male Farm Servant who has been longest in the same service, and who has proved himself most efficient in his duties, and to have invariably treated the animals under his charge with kindness.
18. Female Servant in charge of Dairy and Poultry who has been longest in the same service, and who has proved herself most efficient in her duties, and to have invariably treated the animals under her charge with kindness.
19. Best Sheep-Shearer.
20. Most expert Hedge-Cutter.
21. Most expert Labourer at Draining.
22. Most expert Farm Servant at trial of Reaping-Machines.
23. Best Maker of Oat-Cakes.

It is left to the local Society to choose out of the foregoing list the classes for which the Medals are to be competed.

The Medals are granted for two years.

In 1889 it was resolved that in future no Society shall receive more than two Medals for two years.

*Aberdeenshire.*

1. CLUNY, MONYMUSK, AND MIDMAR.—*Convener*, Ranald Macdonald, Cluny Castle, Aberdeen; *Secretary*, James Christie, Backhill of Castle Fraser, Kemnay. 2 Medals. 1895.

2. NORTH OF SCOTLAND BEE SOCIETY.—*Convener*, D. C. Darling, 11 Bridge Street, Aberdeen; *Secretary*, A. M. Byres, C.A., 18 Union Terrace, Aberdeen. 2 Medals. 1893. (In abeyance in 1894.)

*Argyllshire.*

3. DUNOON.—*Convener*, John Mercer, Ardnadam, Sandbank; *Secretary*, John Dobie, Clydesdale Bank, Dunoon. 2 Medals. 1894.

*Ayrshire.*

4. DALRYMPLE.—*Convener*, Alex. Calderwood, Perclewan, Dalrymple; *Secretary*, John Murchie, Netherton, Dalrymple. 2 Medals. 1895.

5. GIRVAN.—*Convener*, The Earl of Stair, K.T., Bargany House, Girvan; *Secretary*, Andrew Dunlop, Royal Bank, Girvan. 2 Medals. 1894.

6. MONKTON, NEWTON, PRESTWICK, AND ST QUIVOX.—*Convener*, John Russell, Craigie Home Farm, Ayr; *Secretary*, James Andrew, Prestwick. 2 Medals. 1894.

7. WEST KILBRIDE.—*Convener*, John Crawford, Millstonford, West Kilbride; *Secretary*, William Logan, Glenhead, West Kilbride. 2 Medals. 1894.

*Berwickshire.*

8. LAUDERDALE BEE-KEEPERS.—*Convener*, Geo. L. Broomfield, Lauder; *Secretary*, Robert Robson, Lauder. 2 Medals. 1894.

9. LAUDERDALE ORNITHOLOGICAL.—*Convener*, Geo. Beveridge, Waterloo, Lauder; *Secretary*, George Westwood, Lauder. 2 Medals. 1895. (In abeyance in 1895.)

*Dumfriesshire.*

10. MOFFAT AND UPPER ANNANDALE.—*Convener*, John Waugh, Granton, Moffat; *Secretary*, William Tait, Church Place, Moffat. 2 Medals. 1894.

11. SOUTH OF SCOTLAND BEE-KEEPERS.—*Convener*, Thomas Kennedy Newbigging, Stewart Hall, Dumfries; *Secretary*, William Wilson, Acrehead, Dumfries. 2 Medals. 1895.

*Fifeshire.*

12. WESTERN DISTRICT OF FIFE.—*Convener*, John Stevenson, Lilliehill, Dunfermline; *Secretary*, Robert Husband, Solicitor, Dunfermline. 2 Medals. 1895.

*Haddingtonshire.*

13. UNITED EAST LOTHIAN.—*Convener*, Charles Smith, Whittinghame, Prestonkirk; *Secretary*, John Stirling, Solicitor, Haddington. 2 Medals. 1895.

*Inverness-shire.*

14. NORTH UIST.—*Convener*, Sir John Campbell Orde, Bart.; *Secretary*, James M. Fraser, Banker, Lochmaddy. 2 Medals. 1893. (In abeyance in 1894.)

*Kirkcudbrightshire.*

15. CARSPHAIRN.—*Convener*, W. Kennedy, Claremont, Ayr; *Secretary* John Galloway, Carsphairn, Galloway. 2 Medals. 1894.

*Lanarkshire.*

16. CARMICHAEL.—*Convener*, Sir W. C. J. C. Anstruther, Bart., Carmichael House, Thankerton; *Secretary*, William Adamson, Devonside, Thankerton. 2 Medals. 1895.

17. SHETTLESTON AND CHRYSTON.—*Convener*, Alex. Murdoch, Gartcraig, Shettleston; *Secretary*, James Denholme, Cardowan, Shettleston. 2 Medals. 1893. (In abeyance in 1894.)

*Nairnshire.*

18. NAIRNSHIRE ORNITHOLOGICAL.—*Convener*, Robert Anderson of Lochdhu, Nairn; *Secretary*, R. S. Falconer, 18 Falconer's Lane, Nairn. 2 Medals. 1894.

*Peeblesshire.*

19. UPPER TWEEDSIDE.—*Convener*, G. Deans Ritchie, Chapelgill, Broughton; *Secretary*, Duncan M. Fletcher, Drumelzier Place, Broughton. 2 Medals. 1894.

*Ross-shire.*

20. NORTHERN PASTORAL CLUB.— *Convener*, ; *Secretary*, Alexander Gunn, V.S., Beauly. 2 Medals 1894.

*Roxburghshire.*

21. LIDDESDALE.—*Convener*, George L. Oliver, Whithaugh, Newcastleton; *Secretary*, Alexander Thomson, Banker, Newcastleton. 2 Medals. 1894.

*Stirlingshire.*

22. CAMPSIE, STRATHBLANE, AND BALDERNOCK.—*Convener*, R. M'Indoe, Knowehead, Campsie Glen; *Secretary*, James N. Paul, Ibert, Killearn. 2 Medals. 1895.

23. SLAMANNAN.—*Convener*, James M'Killop, Polmont Park, Polmont; *Secretary*, Matthew Dunlop, North End, Slamannan. 2 Medals. 1895.

Applications from other Districts must be lodged with the Secretary of the Society *by 1st November next.*

RULES OF COMPETITION.

1. All Competitions must be at the instance of a local Society.

2. The classes for which Medals are granted must be in accordance with the list at page 50. The Committee shall select the classes, and specify them in the return.

3. A Committee of Management shall be appointed, and the Convener of the Committee must be a Member of the Highland and Agricultural Society.

4. The Money Premiums given in the District must be not less than £2 for each Medal claimed.

5. The Medal for Sheep-Shearing shall not be awarded unless there are three competitors, and it shall always accompany the highest Money Premium. There must not be fewer than two competitors in all the classes.

6. Blank reports will be furnished to all the Conveners and Secretaries of the different Districts. These must, in all details, be completed and lodged with the Secretary *on or before the* 1*st of November next*, with the exception of green crop reports, which must be forwarded on or before the 20th of December, for the approval of the Directors, against whose decisions there shall be no appeal.

7. When a grant has expired, the District cannot apply again for aid for two years; and if no competition takes place in a District for two years, the grant expires.

## PLOUGHING COMPETITIONS.

The Minor Silver Medal will be given to the winner of the first or highest Premium at Ploughing Competitions, provided a Report in the following terms is made to the Secretary, within one month of the Competition, by a Member of the Society:—

FORM OF REPORT.

I, of , Member of the Highland and Agricultural Society, hereby certify that I attended the Ploughing Match of the Association at in the county of on the when ploughs competed; of land were assigned to each, and hours were allowed for the execution of the work. The sum of £ was awarded in the following proportions, viz.:—

[*Here enumerate the names and designations of successful Competitors.*]

RULES OF COMPETITION.

1. All Matches must be at the instance of a local Society or Ploughing Association, and no Match at the instance of an individual, or confined to the tenants of one estate, will be recognised.

2. The title of such Society or Association, together with the name and address of the Secretary, must be registered with the Secretary of the Highland and Agricultural Society, 3 George IV. Bridge, Edinburgh.

3. Not more than one Match in the same season can take place within the bounds of the same Society or Association.

4. All reports must be lodged within one month of the date of the Match, and certified by a Member of the Highland and Agricultural Society who was present at it.

5. A Member can only report one Match; and a Ploughman cannot carry more than three Medals in the same season.

6. To warrant the grant of the Medal there must have been twelve ploughs in Competition, and Three Pounds awarded in Premiums by the local Society. The Medal to be given to the winner of the first or highest prize.

7. Ploughmen shall not be allowed any assistance, and their work must not be set up nor touched by others; on land of average tenacity the ploughing should be at the rate of an imperial acre in ten hours, and attention should be given to the firmness and sufficiency of the work below more than to its neatness above the surface.

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## CLASS III.

## COTTAGES AND GARDENS.

The following Premiums are offered for Competition in the Parishes after mentioned.

The Premiums are granted for two years.

### PREMIUMS FOR BEST KEPT COTTAGES AND GARDENS.

| | | | | |
|---|---|---|---|---|
| 1. | Best kept Cottage | £1 | 0 | 0 |
| | Second best | 0 | 10 | 0 |
| 2. | Best kept Cottage Garden | 1 | 0 | 0 |
| | Second best | 0 | 10 | 0 |

#### RULES OF COMPETITION.

1. Competitions may take place in the different parishes for Cottages and Gardens, or for either separately.

2. The occupiers of Lodges at Gentlemen's Approach Gates and Gardeners' Houses are excluded, as well as others whom the Committee consider, from their position, not to be entitled to compete. The inspection must be completed by the 1st of October. In making the inspection, the Conveners may take the assistance of any competent judges.

3. It is left to the Committee of the District to regulate the maximum annual rent of the Cottages, which may, with the garden, be from £5 to £7.

4. To warrant the award of full Premiums, there must not be fewer than three competitors in each class. If there are less than three competitors in each class, only half Premium will be awarded.

5. A person who has gained the highest Premium cannot compete again.

6. If the Cottage is occupied by the proprietor, the roof must be in good repair; if the roof is thatch, it must be in good repair, though in the occupation of a tenant. The interior and external conveniences must be clean and orderly; the windows must be free of broken glass, clean, and affording the means of ventilation. Dunghills, and all other nuisances, must be removed from the front and gables. In awarding the Cottage Premiums,

preference will be given to Competitors who, in addition to the above requisites, have displayed the greatest taste in ornamenting the exterior of their houses, and the ground in front and at the gables.

7. In estimating the claims for the Garden Premiums, the judges should have in view—the sufficiency and neatness of the fences and walks; the cleanness of the ground; the quality and choice of the crops; and the general productiveness of the garden.

8. Reports, stating the number of Competitors, the names of successful parties, and the nature of the exertions which have been made by them, must be transmitted by the Conveners to the Secretary *on or before the* 1*st November next.*

9. When a grant has expired, the District cannot apply again for aid for two years.

Parishes desirous of these Premiums must lodge applications with the Secretary *on or before the* 1*st November next.*

## MEDALS FOR COTTAGES AND GARDENS OR GARDEN PRODUCE.

The Society will issue annually two Minor Silver Medals to a limited number of local Associations or individuals, who at their own expense establish Premiums for Cottages or Gardens under £15 of Rent. The Medals may be awarded for best kept Cottage, and best kept Garden or Flower Plot, or Garden Produce, the produce of the cottager's own garden.

Local Associations or individuals desirous of these Medals, must lodge applications with the Secretary *on or before the* 1*st November next.*

The Medals are granted for two years.

*Aberdeenshire.*

1. Drumblade.—*Convener*, George A. Ferguson, Lessendrum, Huntly; *Secretary*, Alex. Simpson, Slioch, Huntly. 2 Medals. 1895.

*Ayrshire.*

2. Darvel. — *Convener*, James Armour, Glaister, Darvel; *Secretary*, Matthew Mair, Auchinbart, Newmilns. 2 Medals. 1895.

*Banffshire.*

3. Lintmill.—*Convener*, C. Y. Michie, Cullen House, Cullen; *Secretary*, George Bruce, Tochineal, Cullen. 2 Medals. 1894. (In abeyance in 1894.)

*Fifeshire.*

4. Dysart.—*Convener*, James Allan, Dysart; *Secretary*, Peter Buist, 14 Alexander Street, Dysart. 2 Medals. 1895.

5. Kingskettle.—*Convener*, William Dingwall, Ramornie, Ladybank; *Secretary*, David Beveridge, Kettle. 2 Medals. 1895.

6. Letham and District.—*Convener*, Thomas Webster, Nisbetfield, Ladybank; *Secretary*, Robert J. P. Spence, Letham, Collessie. 2 Medals. 1894.

*Forfarshire.*

7. Panbride and Arbirlot.—*Convener*, George Cowe, Balhousie, Carnoustie; *Secretary*, James Kydd, Scryne, Carnoustie. 2 Medals. 1894.

*Haddingtonshire.*

8. PENCAITLAND.—*Convener*, William Stodart, Wintonhill, Tranent; *Secretary*, Peter Cossar, Pencaitland. 2 Medals. 1895.

*Kirkcudbrightshire.*

9. KIRKPATRICK-DURHAM.—*Convener*, James M'Queen of Crofts, Dalbeattie; *Secretary*, David C. G. Johnston, Kirkpatrick-Durham, Dalbeattie. 2 Medals. 1895.

*Lanarkshire.*

10. NEW VICTORIA GARDENS, POLLOKSHIELDS.—*Convener*, ; *Secretary*, S. M. Wellwood, 68 Kenmure Road, Pollokshields. 2 Medals. 1894.

*Nairnshire.*

11. NAIRNSHIRE.—*Convener*, Robert Anderson of Lochdhu, Nairn; *Secretary*, J. M'Intosh, Nairn. 2 Medals. 1895.

*Perthshire.*

12. ALMOND VALLEY. — *Convener*, J. D. Lumsden, Huntingtowerfield, Perth; *Secretary*, James Anderson, jun., Huntingtowerfield, Perth. 2 Medals. 1895.

13. BREADALBANE, GLENLYON, WEEM, STRATHTAY, AND GRANTULLY.—*Convener*, Peter Haggart, Breadalbane Mills, Aberfeldy; *Secretary*, Robert Reid, Ashville, Aberfeldy. 2 Medals. 1894.

14. DUNNING.—*Convener*, Robert Gardiner, Henhill, Forteviot; *Secretary*, Johnstone Wright, Dunning. 2 Medals. 1895.

15. MENZIES FLOWER SHOW.—*Convener*, Sir Robert Menzies of that Ilk, Bart.; *Secretary*, A. T. Ross, Schoolhouse, Weem, Aberfeldy. 2 Medals. 1894.

16. MEIGLE.—*Convener*, John Yeaman, Royal Bank, Alyth; *Secretary*, James Armitt, Crathie House, Meigle. 2 Medals. 1895.

17. STANLEY.—*Convener*, C. A. Murray, Taymount, Stanley; *Secretary*, James Haggart, Percy Street, Stanley. 2 Medals. 1894.

*Renfrewshire.*

18. BRIDGE OF WEIR.—*Convener*, A. M. Brown, Gryffe Castle, Bridge of Weir; *Secretary*, William Mason, Bridge of Weir. 2 Medals. 1895.

*Stirlingshire.*

19. FALKIRK. — *Convener*, John Shields, Linlithgow; *Secretary*, John Fleming, 158 High Street, Falkirk. 2 Medals. 1894.

*Wigtownshire.*

20. WIGTOWNSHIRE.—*Convener*, ; *Secretary*, James Ross, County Buildings, Stranraer. 2 Medals. 1894.

REGULATIONS.

1. Competitions may take place in the different districts for Cottages and Gardens, or for either separately.

2. The annual value of each Cottage, with the ground occupied in the parish by a Competitor, must not exceed £15. The occupiers of Lodges at Gentlemen's Approach Gates, and Gardeners in the employment of others, are not entitled to compete.

3. If Competition takes place for Garden Produce in place of the best kept Garden, such produce must be *bona fide* grown in the Exhibitor's Garden, and he will not be allowed to make up a collection from any other Garden.

4. To warrant the award of the Medals, there must not be fewer than three Competitors.

5. Blank reports will be furnished to the Conveners and Secretaries of the different Districts. These must, in all details, be completed and lodged with the Secretary *on or before the* 1*st November next*, for the approval of the Directors, against whose decisions there shall be no appeal.

6. When a grant has expired, the District cannot apply again for aid for two years, and if no competition takes place in a District for two years the grant expires.

## IMPROVING EXISTING COTTAGES.

To the Proprietor in Scotland who shall report the Improvement of the greatest number of Cottages during the years 1892, 1893, and 1894—The Gold Medal.

## BUILDING NEW COTTAGES.

To the Proprietor in Scotland who shall report the Erection of the greatest number of approved Cottages during the years 1891, 1892, 1893, and 1894—The Gold Medal.

RULES OF COMPETITION.

1. Claims for the Premiums must be lodged with the Secretary on or before the 1st of October next, to allow an inspection to be made of the different Cottages. The inspection will be conducted by a Committee of the Society's Members, and Reports must be transmitted to the Secretary *on or before the* 1*st November next.*

2. The annual value of the Cottage or Cottages separately, with the garden ground, must not exceed £5.

3. In estimating the claims of the Competitors, the following points will be kept in view: The external appearance of the Cottages; their internal accommodation; the arrangements of the out-houses; the means of drainage and ventilation; and the expense of the building or of the alteration, compared with its durability and accommodation. When the Cottages of one Competitor are superior in style and comfort to those of another, though not so numerous, the Inspectors will give them preference, provided they amount at least to three, and have been erected at a moderate expense.

4. Parties competing will forward to the Society Plans, Specifications, and Estimates, of which, and of all information sent therewith, copies may be taken for publication, if the Society shall see fit, and the originals returned to the parties within six months, if desired.

**Subject to Orders issued by the Board of Agriculture**

# HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

## GENERAL SHOW OF STOCK AND IMPLEMENTS AT TERREGLESTOWN DUMFRIES

ON 23D, 24TH, 25TH, AND 26TH JULY 1895.

*LAST DAYS OF ENTRY.*

IMPLEMENTS AND OTHER ARTICLES—Monday, 20th May.

STOCK, POULTRY, AND DAIRY PRODUCE—Monday, 17th June.

No Entry at ordinary fees taken later than those which are received at the Society's Office, Edinburgh, by first post, or 10 o'clock, on Monday morning (17th June). Post Entries for Cattle, Horses, Sheep, and Swine taken on payment of 10s. additional for each entry (Poultry at double fees) till Wednesday morning (19th June), at the Society's Office, Edinburgh, at 10 o'clock.

COVERED BOOTHS FOR OFFICES—Monday, 17th June.

### President of the Society.

THE DUKE OF BUCCLEUCH AND QUEENSBERRY, K.T.

### Chairman of the Board of Directors.

SIR JAMES H. GIBSON-CRAIG, BART.

### Convener of the Local Committee.

WELLWOOD H. MAXWELL OF MUNCHES.

**The District connected with the Show comprises the Counties of Dumfries, Kirkcudbright, and Wigtown.**

## REGULATIONS.

### GENERAL CONDITIONS.

1. The Competition, except where otherwise stated, is open to Exhibitors from all parts of the United Kingdom.

2. Every Lot must be intimated by a Certificate of Entry, lodged with the Secretary *not later than Monday, 20th May, for Implements and other* *Entri*

*Articles, and Monday, 17th June, for Stock, Poultry, and Dairy Produce.* No Entry taken at ordinary fees later than those which are received at the Society's Office by first post, or 10 o'clock, on Monday morning, 17th June. Post Entries for Cattle, Horses, Sheep, and Swine taken on payment of 10s. additional for each entry (Poultry at double fees) till Wednesday morning (19th June), at the Society's Office, Edinburgh, at 10 o'clock. Printed forms of Entry will be issued on application to the Secretary, No. 3 George IV. Bridge, Edinburgh. Admission Orders will be forwarded to Exhibitors, by post, previous to the Show.

*Protests.* 3. Protests against the awards of the Judges, or against a violation of the judging regulations, must be lodged with the Secretary, at his Office in the Showyard, not later than 9 A.M. on Wednesday, the second day of the Show, and parties must be in attendance at the Committee Room, in the Showyard, at 9.30 A.M. that day, when protests will be disposed of. All protests must be accompanied by a deposit of £2, 2s., and if not sustained the sum may be forfeited at the discretion of the Directors.

4. Protests lodged for causes which the protester produces no good evidence to substantiate will render him liable to be reported to the Board of Directors, with the view, if they see reason, of his being prohibited from again entering Stock for a General Show.

*Society not liable.* 5. The Society shall not be liable for any loss or damage which Stock, Poultry, Dairy Produce, Implements, or other articles may sustain at the Show, or in transit.

*Decisions of Board.* 6. The decisions of the Board of Directors are final in all questions respecting Premiums and all other matters connected with the Show, and it shall not be competent for any Exhibitor to appeal against such decisions to, nor seek redress in respect of them from, any other tribunal.

*Covered Booths.* 7. Covered Booths for Offices (9 feet by 9 feet), purely for business, not for exhibition of goods, can be had for £3, 10s. to Members and £5 to Non-Members. Intimation to be made to the Secretary on or before the 17th of June. Those applying after that date to pay double Entry Money, but no application can be received later than 5th July.

*Lights and Smoking.* 8. No lights allowed in the Yard at night, and Smoking is strictly prohibited within the Sheds. Those infringing this Rule shall be liable to a fine of 10s.

*Water.* 9. As the command of water in the Yard is limited, it is particularly requested that waste be avoided.

*Restoring Turf.* 10. When the ground requires to be broken, the turf must be carefully lifted and laid aside, and the surface must be restored to the satisfaction of the Society, and at the expense of the Exhibitor.

*Subjection to Rules.* 11. All persons admitted into the Showyard shall be subject to the Rules and Orders of the Directors.

*Powers of Stewards.* 12. The Stewards have power to enforce the Regulations of the Society in their different departments, and to bring to the notice of the Directors and Secretary any infringement thereof.

*Attendants.* 13. All persons in charge of Stock or other Exhibits shall be subject to the orders of the Secretary and Stewards.

*Violation of Rules.* 14. The violation by an Exhibitor of any one of the Regulations shall render him liable to the forfeiture of all Premiums awarded to him, or of such a portion as the Directors may ordain.

*Railway Passes.* 15. Railway Passes for Stock and Implements are issued to Exhibitors before the Show along with their Tickets of Admission.

*Removal of Exhibits.* 16. No animal or article can be withdrawn before the formal closing of the Show at 5 P.M. on Friday; Steam Engines not till 6 o'clock. Stock and Implements may remain in the Yard till Saturday afternoon.

*Payment of Prizes.* 17. The Premiums awarded, except those withheld till birth of calf or

foal is certified, will be paid in the November following the Show, and, with the exception of the Tweeddale Gold Medal, Special Challenge Cups, and the Silver Medals, may be taken either in money or in plate.

## STOCK AND POULTRY.

18. Poultry and Stock will be admitted on Monday, the day before the opening of the Show, and, with the exception of Horses, must be in the Yard before 12 o'clock that night. Horses must be in before 8 o'clock on the morning of Tuesday, except those entered for Jumping only, regarding which special Regulations will be found beside the list of prizes for Jumping. Judging begins at 10 A.M. on Tuesday. Exhibited on Tuesday, Wednesday, Thursday, and Friday. Stock may be admitted on the Saturday preceding the Show, but only by sending two days' prior notice to the Secretary. *Admission of Stock.*

19. An animal which has gained a first Premium at a General Show of the Society cannot again compete in the same class, but may be exhibited as Extra Stock. *Former Winners.*

20. All animals, except calves, foals, and lambs shown with their dams, must be entered in the classes applicable to their ages, and cannot be withdrawn after entry, or other animals be substituted in their place. *No substitution of animals.*

21. For prizes given by the Society, no animal shall be allowed to compete in more than one class, except in the Jumping and Driving Competitions. *One class only.*

22. Shorthorn, Aberdeen-Angus, Galloway, and West Highland animals must be entered in the herd-books, or the Exhibitor must produce evidence that his animal is eligible to be entered therein. *Herd-books.*

23. Stock must be *bona fide the property of* the Exhibitor on the last day of Entry. *Ownership.*

24. The Schedule of Entry must be filled up so far as within the knowledge of the Exhibitor. The Society shall have power at any time to call upon an Exhibitor to furnish proof of the correctness of any statement in his entry.

25. The name of the Breeder, if known, must be given, and if the Breeder is not known, a declaration to that effect, signed by the Exhibitor, must be sent along with the Schedule, and no pedigree will be entered in the Catalogue when the Breeder is unknown. *Particulars of entries.*

26. Should it be proved to the satisfaction of the Directors that an animal has been entered under a false name, pedigree, or description, for the purpose of misleading the Directors or Judges as to its qualification or properties, or that information required in the Schedule and known or easily ascertained by the Exhibitor has been withheld, such animal may be disqualified either before or after a prize has been awarded to it, and the case may be reported to the Directors, in order that the Exhibitor may be disqualified from again competing at the Society's Shows, or his case otherwise disposed of as the Directors may determine. *Entries disqualified.*

27. When an animal has previously been disqualified by the decision of any Agricultural Association in the United Kingdom, such disqualification shall attach, if the Exhibitor, being aware of the disqualification, fail to state it, and the grounds thereof, in his entry, to enable the Directors to judge of its validity. Any person who is disqualified from exhibiting at any Show in the United Kingdom shall be prohibited from exhibiting at any General Show of the Society, unless with the special consent of the Board.

28. All Horses or Ponies entered in classes in which a particular height is stated shall before being judged be measured with their shoes on. No subsequent measuring or alteration of shoes will be permitted. *Height of Horses.*

*Overfeeding.* 29. Breeding Stock must not be shown in an improper state of fatness, and the Judges are requested not to award Premiums to overfed animals; and no Cattle or Sheep which have been exhibited as Fat Stock at any Show are eligible to compete in the Breeding Classes for the Society's Prizes.

*Parades.* 30. Horses and Cattle must be paraded at the times stated in the Programme of the Show, and when required by the Stewards, and under their direction. Prize and commended animals will receive two rosettes each, which must be attached to the head of the animal, one on each side. Attendants must be beside their animals *twenty minutes before the hour of Parade*, and be ready to proceed to the ring immediately on receiving the order of the Stewards. Infringement of this Rule, or failure of any attendant to obey the orders of the Society's officials, will render the Exhibitor liable to a fine of 20s., and to the forfeiture of any or all of the Prizes awarded to him at this Show.

*Responsibility of Exhibitors.* 31. Exhibitors shall be answerable for all acts, whether committed by themselves, their servants, or others in charge of their Stock, and shall be responsible for the condition of their animals during the whole time they remain in the Showyard.

*Authority for removal.* 32. No animal shall be taken out of its stall after 10 A.M. during the Show except by order of the Stewards, or with permission of the Secretary. Those infringing this Rule shall be liable to a fine of 10s.

*Sires.* 33. Aged Bulls and Stallions must have had produce, and, along with two-year-old Bulls, three-year-old Colts, and two-shear and aged Tups, have served within the year of the Show.

*Cows.* 34. All Cows must have had calves previous to the Show, and when exhibited they must either be in milk or in calf: if in milk, birth must have been within 9 months of the Show; if in calf, birth must be certified within 9 months after the Show. This Rule does not apply to animals in Family Groups. Ayrshire Heifers in calf must produce a calf within one month of the first day of the Show.

*Family Groups.* 35. Cows in Family Groups must have had calves previous to the Show, and when exhibited they must be either in milk or in calf. Two-year-old Heifers in Family Groups must be certified to have been served before the Show, except Highland Heifers, which need not be served till 3 years old.

*Ayrshire Cows.* 36. All Milk Cows of the Ayrshire breed must be in the Yard on the evening of Monday, the day before the opening of the Show, before 8 o'clock, after which they will be inspected by the Veterinary Surgeon, or other official of the Society, between 8 and 9 o'clock, to see if they have been milked dry; and if not, they must be milked under his direction, and, after the judging, all Milk Cows must be milked morning and evening.

*Tampering with animals.* 37. Any artificial contrivance or device of any description found on or proved to have been used on an animal, either for preventing the flow of milk or for any other improper purpose, will disqualify that animal from being awarded a Premium, and the Owner of said animal shall be prohibited from again entering Stock for any of the Society's General Shows, for such a period as the Directors may see fit.

*In-calf Heifers.* 38. Two-year-old Heifers—of the Shorthorn, Aberdeen-Angus, and Galloway breeds—must be in calf when exhibited, and the Premiums will be withheld till birth be certified, which must be within 9 months after the Show. This Rule does not apply to animals in Family Groups.

39. Animals of any age that have had a calf must be shown as Cows.

*Mares.* 40. Agricultural Mares with foal at foot must have produced foals after 1st January of the year of the Show. In the case of a Mare whose foal has died, she shall without further entry be eligible to compete among the Yeld Mares. Agricultural Yeld Mares must produce a foal within 12 months from the first day of the Show.

*Calves and Foals.* 41. With reference to Regulations 34 and 38, birth of at least a seven

months' calf must be certified; and in regard to Regulation 40, birth of at least a nine months' foal; or in the case of death, a Veterinary Surgeon's certificate must be produced certifying that at the time of death the animal was so far advanced with calf or foal that if it had lived it would have produced a calf or foal, as required by Rules 34, 38, 40, and 41.

42. No rug shall be hung up so as to conceal any animal in a horse-box or stall, except with special permission of the Steward of that department. *Concealing animals.*

43. Horses entered as Hunters must be jumped if required by the Judges. *Hunters.*

44. Judges are particularly requested to satisfy themselves, as far as possible, regarding the soundness of all Horses before awarding the Prizes, and to avoid giving a preference to animals showing symptoms of hereditary diseases. The Judges may consult the Society's Veterinary Surgeon if they deem it expedient. No protests on veterinary grounds will be received. *Soundness of Horses.*

45. All Ewes must have reared lambs in the year of the Show; and Ewes of the Blackfaced and Cheviot breeds must be in milk, and have their lambs at foot. *Ewes.*

46. Sheep must have been clipt bare after 1st January of the year of the Show, and the Judges are instructed to examine the fleeces of the Sheep selected for Prizes, and to cast those on which they find any of the former fleece. *Clipping.*

47. Sows must have reared pigs in the year of the Show or be in pig; and Pigs must belong to the same litter, and be uncut. *Sows.*

48. In Poultry the Aged Birds must have been hatched previous to, and Cockerels and Pullets in, the year of the Show. *Poultry.*

49. Bulls must be secured by nose-rings, with chains or ropes attached, or with strong halters and double ropes. All Cattle must be tied in their stalls. *Securing Cattle.*

50. Servants in charge of Stock must bring their own buckets or pails, and a piece of rope or sheep-net to carry their forage. Mangers, sheep and pig troughs, will be provided. *Feeding appliances.*

51. Loose-boxes will be provided for Stallions, three, two, and one year-old entire Colts and Fillies, and for Mares with foals at foot; closed-in stables for all the other Horses, and covered accommodation for the whole of the other Live Stock. Stalls for attendants on Cattle, Horses, and Sheep will be provided at same rates as those charged for Stock. *Accommodation for animals.*

52. Five days' supply of straw, hay, grass, and tares will be provided free by the Society. Any additional fodder or other kinds of food required will be supplied at fixed prices in the Forage-yard. Any servant removing bedding from an adjoining stall will be fined in double the amount taken. Exhibitors may fetch their own cake or corn to the Yard, but not grass, tares, hay, or straw. Coops, food, and attendance for Poultry will be provided by the Society. *Fodder.*

53. Cattle, Sheep, Swine, or Poultry cannot be removed from the Yard till 5 P.M. on Friday, the last day of the Show, except on certificate by the Veterinary Surgeon employed by the Directors, countersigned by the Steward of the department and the Secretary. *Removal.*

54. Horses may be withdrawn at 6 o'clock on Tuesday evening, and at 8 o'clock on Wednesday and Thursday evenings, on a deposit of £5 for each animal, which shall be forfeited, along with any prize-money it may have gained, if the animal is not brought back. They must return between 7 and 7.30 the following morning, and those not in before 8 shall forfeit 10s. Horse passes to be applied for at the Committee Room between 5 and 6 P.M. on Tuesday, and the deposit, unless forfeited in whole or in part, will be returned between 12.30 and 2.30 on Friday. *Withdrawal of horses over night.*

55. When the Stock is leaving the Yard, no animal is to be moved till ordered by those in charge of clearing the Yard. Those transgressing this Rule shall be liable to a fine of 10s., and detained till all the other Stock is removed. *Order in removal.*

## JUDGING STOCK AND POULTRY.

*Opening Gates.* 56. On Tuesday, the first day of the Show, no person will be admitted, except Servants in charge of Stock, till 8 A.M., when the Gates are opened to the public.

*Judging.* 57. The Judges will commence their inspection at 10 A.M. The spaces reserved for the Judging will be enclosed, and no encroachment shall be permitted. In no case shall a Premium be awarded unless the Judges deem the animals to have sufficient merit; and where only one or two lots are presented in a section, and the Judges consider them unworthy of the Premiums offered, it shall be in their power to award a lower prize, or to suggest the removal of any lot which appears to them unworthy of a place in the Yard.

*Commendations.* 58. In addition to the Premiums, the Judges are authorised to award three Commendations in each section (except Poultry, where only two Prizes and one Commendation are to be awarded), if the entries are numerous and the animals of sufficient merit. These Commendations consist of—Very Highly Commended, Highly Commended, and Commended.

*Ayrshire Cows and Heifers.* 59. Ayrshire Cows which have not calved before the Show, whether entered in the class for Cows in Milk or for Cows in Calf, shall be judged along with the Cows in Calf, and Ayrshire Cows or Heifers which have calved before the Show—in whichever of the two classes entered—shall be judged along with Cows in Milk.

*Attending Members.* 60. One Member of Committee and one or two Directors shall attend each section of the Judges. It will be their duty to bring the animals out to the Judges and to see that no obstruction is offered to them, and that the space reserved for them is not encroached upon; to ticket the prize animals; to send the Nos. of prize animals to the Award Lectern; to assist the Judges in completing their return of awards; and should any difficulty arise, to communicate with the Stewards or Secretary.

61. It shall not be competent for any Exhibitor, nor for his Factor or Land-Steward, to act as a Judge or attending Member in any class in which he is competing.

## DAIRY PRODUCE.

62. Dairy Produce will be received in the Showyard on Monday, the day before the opening of the Show, and till 8 A.M. on Tuesday, the first day of the Show. Judged at 10 A.M. on Tuesday. Exhibited Tuesday, Wednesday, Thursday, and Friday.

63. Dairy Produce must have been made on the Exhibitor's farm this year. No Exhibitor shall show more than one lot in each class. At least 1 cwt. of the variety of Butter exhibited must have been made during the Season. The lots must be fair samples. No lot can be removed from the Yard till 5 P.M. on Friday, the last day of the Show. The Society undertakes no responsibility for the receipt or despatch of exhibits.

## STALL RENT.

64. The following rates shall be paid by Exhibitors when making their Entries :—

| | Members. s. | d. | Non-Members. s. | d. |
|---|---|---|---|---|
| Stalls for Cattle, each | 15 | 0 | 25 | 0 |
| Boxes for Stallions over 12 hands, and for 3 and 2 year-old entire Colts | 30 | 0 | 40 | 0 |
| Boxes for Mares, over 12 hands, with Foal at foot | 30 | 0 | 40 | 0 |
| Boxes for one-year-old entire Colts and Fillies | 20 | 0 | 30 | 0 |
| Boxes for Stallions, 12 hands and under | 20 | 0 | 30 | 0 |
| Boxes for Mares, 12 hands and under, with Foal at foot | 20 | 0 | 30 | 0 |
| Stalls for Mares or Geldings, 12 hands and under | 15 | 0 | 20 | 0 |
| Stalls for all other Horses, each | 20 | 0 | 30 | 0 |
| Shed Accommodation for Machines for driving competitions, each | 5 | 0 | 10 | 0 |
| Sheep, per pen | 10 | 0 | 15 | 0 |
| Swine, per pen | 15 | 0 | 20 | 0 |
| Poultry, each entry | 3 | 0 | 5 | 0 |
| Dairy Produce, each entry | 4 | 0 | 6 | 0 |
| Stalls for Attendants and Stalls for Shepherds, same rates as above. | | | | |
| Covered Booths for offices, 9 feet by 9 feet | 70 | 0 | 100 | 0 |
| Newspaper offices . . £2, 10s. | | | | |

*Entries in more than one Class.*—In the case of cattle, horses, sheep, or swine entered in more than one class, the entry fee shall be five shillings for each class after the first. This does not apply to the Jumping Competitions.

## FINES FOR STOCK NOT FORWARD.

65. In order to lessen the number of vacant Stalls, the following fines shall be imposed on all Exhibitors whose animals are not forward : For Horses, 40s.; Cattle, 20s.; Sheep and Swine, 10s.; Poultry, 3s.;—this fine to be in addition to Entry Money. In the case of death or illness of an animal, a Veterinary Surgeon's Certificate is necessary for a remit of the fine. The absent animals must be reported by the Stewards to the Secretary.

## EXTRA STALL FOR ATTENDANTS.

66. Exhibitors of Stock shall be entitled to take an extra Stall for the accommodation of their attendants without being liable to a fine, but they must state when making their Entry that the Stall is to be used for that purpose, and remit rent.

## IMPLEMENTS AND OTHER ARTICLES.

67. Implements will be received in the Yard from Tuesday, 16th July, till 5 o'clock on the afternoon of Monday, 22d July. Exhibited Tuesday, Wednesday, Thursday, and Friday. The Schedule of Entry must be filled up so far as within the knowledge of the Exhibitor, and prices must be stated. *Admission.*

68. No Money Prizes or Medals will be given by the Society for Implements of any kind. *Premiums.*

69. Agricultural Implements, and Implements and collections of articles not Agricultural, will be received for Exhibition, but the Secretary is entitled to refuse Entries from dealers in articles not deemed worthy of Exhibition. *Refusing Entries.*

*Local Operatives.* 70. In order to encourage exhibits of Agricultural Implements from operative Blacksmiths and Carpenters in the district of the Show, open space will be provided for these in some less prominent part of the Yard at a charge of Entry Money of 1s. per running foot of frontage, 20 feet deep.

*Order of Implements.* 71. Implements will be entered in the following sections—viz., 1st, Under Cover, for Agricultural Implements; 2d, Open, for Agricultural Implements; 3d, Exhibits not Implements of Husbandry, either under cover or open, as may be deemed necessary by the Secretary; 4th, Motion Yard; 5th, Open space for Agricultural Implements from operative Blacksmiths and Carpenters in the district of the Show. Exhibitors must specify the space they require.

*Articles not entered.* 72. Every article to be exhibited must be entered on the Society's Entry Form. Any article not so entered that is taken to the Show is liable to be ordered out of, or removed from, the Showyard, or confiscated to the Society. Exhibitors infringing this rule are moreover liable to a fine of £1.

*Selling by auction and noisy behaviour forbidden.* 73. "Cheap-Jacks" are not admitted to the Showyard. The selling of goods by auction, shouting, and other behaviour calculated to annoy visitors or Exhibitors, are strictly forbidden. Exhibitors infringing this Regulation are liable to a fine of £1, and to have themselves and their goods ordered out of, or removed from, the Showyard, or to have their goods confiscated to the Society.

*Placing Exhibits. Removing Exhibits.* 74. The articles of each Exhibitor must be all placed in one stand, except Implements in motion, and must not on any account extend beyond the width allowed. No article shall be moved out of its stand, or the stand dismantled, till the termination of the Show, at 5 P.M. on Friday. Those infringing this Rule shall be liable to a fine of 10s.

*Arranging Exhibits.* 75. Exhibitors must arrange their own articles *within* the space allotted to them before 9 o'clock on Tuesday, and to the satisfaction of the Stewards in charge of the Implement Yard.

*Handbills.* 76. Exhibitors are not allowed to distribute handbills anywhere in the Yard except at their own Stand; and they must not for this or any other purpose encroach upon the adjacent alleys or open spaces.

*Sweeping Stands, &c.* 77. Exhibitors are required to have their Stands and the portions of the alleys immediately adjoining them swept up before eight o'clock on each morning of the Show.

*Fuel.* 78. All Machines requiring steam or fire must be entered as such in the Certificate, and will be placed in the Motion Yard. *Coke only shall be used in all cases where fire is required after* 10 *o'clock* A.M. Those infringing this Rule shall incur a penalty of £5.

*Steam Engines.* 79. No Steam Engine shall be driven in the Yard at a greater speed than 4 miles an hour.

80. Locomotive and Traction Engines and other Machines must not be moved from their places without permission of the Secretary or Stewards, and must not leave their stands till 6 P.M. on Friday.

*Consigning Implements.* 81. There must be attached to each Implement, when forwarded to the Show, a label bearing the Exhibitor's name, and that of the Implement, as well as the number of the Exhibitor's stand.

82. The carriage of all Implements must be prepaid.

*Exhibitors' and Attendants' Tickets.* 83. Each Exhibitor in the Implement Department will receive one free Ticket of Admission to the Showyard for himself or a member of his firm, and will receive, in addition, for the use of attendants employed by him at his Stand, three Tickets of Admission for each complete ten feet of shedding in the Motion Yard, and two Tickets for each complete ten feet of shedding in the other sections. No additional Free Tickets can be issued in any circumstances whatever.

*Tickets to be filled* 84. The Free Tickets of Admission referred to in the foregoing Regulation will be issued to the Exhibitors in blank, but the name of the

person for whom it is intended must be written on it before it is used. Each person holding a Free Ticket of Admission must sign his or her name on the back thereof, and must also, when required, sign his or her name in the book at the Entrance Gate. Exhibitors' attendants are strictly cautioned not to lend or transfer their Tickets, which can be used only by the persons whose names they bear, and who must be *bona fide* acting for, or employed by, the Exhibitor. No Ticket is transferable. An Exhibitor is liable to a fine of £1 for each case of transfer or other improper use of a Ticket issued to himself or employee.

*up and signed.*

*Tickets not Transferable.*

*Improper use of Tickets.*

STALL RENT.

85. Ground to be taken in spaces of 10 feet frontage by 20 feet deep, except in Motion Yard, which is to be 10 feet or any larger amount of frontage by 50 feet deep. Except for exhibits not agricultural, no boarding shall exceed 4 feet in height.

86. The following rates shall be paid by Exhibitors when making their Entries :—

| | Members. | Non-Members. |
|---|---|---|
| Implement Shedding, 20 feet deep, 7 feet high, per 10 feet . . . . . | £1 5 0 | £1 15 0 |
| Implements without Shedding, 20 feet deep, per 10 feet . . . . . | 1 5 0 | 1 15 0 |
| Implement space in Motion Yard, without Shedding, 50 feet deep, per foot . . | 0 2 6 | 0 3 6 |
| And with Shedding, 20 feet deep, 10 feet high, per foot . . . . . . | 0 6 0 | 0 8 0 |
| Covered Booths for offices, 9 feet by 9 feet, each | 3 10 0 | 5 0 0 |
| Newspaper offices, each . . £2, 10s. | | |

## ADMISSION OF THE PUBLIC.

The public will be admitted daily at 8 A.M. Judging begins on Tuesday at 10 A.M. The charges for admission to the Yard will be—Tuesday, from 8 A.M. till 5 P.M., 5s.; Wednesday, from 8 A.M. till 5 P.M., 3s.; Thursday, from 8 A.M. till 5 P.M., 2s.; Friday, from 8 A.M. till 5 P.M., 1s.

## ADMISSION OF MEMBERS AND EXHIBITORS.

On exhibiting their "*Member's Ticket*," which is strictly not transferable, Members of the Society are admitted free to the Showyard and to the Enclosures and Stands around the Large Ring, excepting the Centre Seats in the Grand Stand, and such other parts as may be reserved for any special purpose. Tickets will be sent to all Members residing in the United Kingdom whose addresses are known, and on no account will duplicates be issued. All Members not producing their tickets must pay at the gates, and the admission money will not on any account be returned.

Exhibitors of Stock (not Members) are admitted free to the Showyard on producing their tickets.

For Exhibitors of Implements and their assistants tickets are issued as provided in the Regulations for Implements.

Tickets for attendants on Stock are not available to admit to the Yard between 11 A.M. and 5 P.M.; and any of these attendants requiring to leave the Yard during the day cannot be again admitted except by a special pass (to be applied for at the Ticket Gate), which must be given up on his return.

Placards, except those of the Society, are prohibited both inside the Showyard and on the outside of the Boundary Fence, with the exception of those belonging to Exhibitors, whose right is confined to their own stalls. No newspapers or any other article allowed to be carried about the Yard for sale or display. No strolling bands or musicians admitted.

*No Carriages or Equestrians admitted without special leave from the Directors, and then only for Invalids. Bath-chairs may be brought in.*

Premium Lists, Regulations, and Certificates of Entry may be obtained by applying at the Secretary's Office, No. 3 George IV. Bridge, Edinburgh.

*All Communications should be addressed to* JAMES MACDONALD, Esq., *Secretary of the Highland and Agricultural Society of Scotland, No.* 3 *George IV. Bridge, Edinburgh.*

*Address for Telegrams*—"SOCIETY," EDINBURGH.

## LAST DAYS OF ENTRY.

IMPLEMENTS AND OTHER ARTICLES—Monday, 20th May.

STOCK, POULTRY, AND DAIRY PRODUCE—Monday, 17th June.

No Entry at ordinary fees taken later than those which are received at the Society's Office, Edinburgh, by first post, or 10 o'clock, on Monday morning (17th June). Post Entries for Cattle, Horses, Sheep, and Swine taken on payment of 10s. additional for each entry (Poultry at double fees) till Wednesday morning (19th June), at the Society's Office, Edinburgh, at 10 o'clock.

COVERED BOOTHS FOR OFFICES—Monday, 17th June.

## RAILWAY ARRANGEMENTS.

The Railway Companies will be furnished with a list of the Exhibitors of Stock and Implements, after the 4th of July, and all applications for horse-boxes and trucks, and for information as to arrangements of Special Trains, must be made by the Exhibitors themselves with the Station-master where their stock is to be trucked.

*The arrangements made by the Railway Companies for the conveyance of Live Stock and Goods to and from the Show are* indicated *in the following, but exhibitors are recommended to apply to the respective companies for* full particulars :—

1. Live Stock and Goods *to* the Show to be charged ordinary rates.

2. Live Stock and Goods *from* the Show, *if sold*, to be charged ordinary rates.

3. Live Stock and Goods *from* the Show, *if unsold*, to be conveyed at half rates back to the station whence they were sent, at owners' risk, on production of a certificate from the Exhibitor to the effect that they are unsold ; failing production of such certificate, ordinary rates must be charged. The reduction to half rate is to be allowed only when the animals or goods are returned by the same route as that by which they were conveyed *to* the Show. The minimum charge for Stock returned at half rates is one-half the ordinary minimum.

*If the unsold Live Stock which was conveyed on the outward journey by Passenger Train in horse-boxes be required to be returned by Goods Train in cattle trucks, half the Goods Train rates must be charged.*

*If the unsold Live Stock which was conveyed on the outward journey by Goods Train in cattle trucks be required to be returned by Passenger Train in horse-boxes, half the Passenger Train rates must be charged.*

4. Unsold Live Stock transferred from one Agricultural Show to another, in another part of the country, must be charged ordinary rates.

5. Unsold goods transferred from one Agricultural Show to another, in another part of the country, will be conveyed at half rates at owners' risk, on production of Certificate from the Exhibitor to the effect that they are unsold; failing production of such certificate, ordinary rates will be charged.

6. Poultry to be charged ordinary rates both ways.

7. Horse-boxes, or other Passenger Train vehicle, must not be provided for the carriage of Live Stock sent by Goods Train and invoiced at Goods Train rates. *For rates for Horse-boxes by Passenger and Special Trains, apply to the Railway Companies.*

8. Provender conveyed to Agricultural Shows with Live Stock is to be charged ordinary rates, except so much of the same as may be required on the journey.

9. Men, certified by the owners to be *bona fide* in charge of Live Stock, to be conveyed free in the same train as the animals; one man to each consignment, or one to each vehicle if the consignment occupy more than one vehicle.

10. The ordinary rates do not include delivery *to*, or collection *from*, the Show ground.

11. Agricultural Societies' Show Plant must be charged at Class C rates, station to station.

12. Tents, Canvas, and other articles carried to Shows, not for exhibition, to be charged the ordinary rates both going and returning.

## DELIVERY CHARGES.

*Rates of Cartage for Delivery and Collection of Live Stock, Implements, and other Articles between the Railway Stations at Dumfries and Maxwelltown and the Showyard.*

1. General traffic, 3s. per ton (minimum per consignment, 1s. 6d.)
2. Implements and Machinery (Agricultural), not exceeding 1 ton each, 4s. per ton (minimum per consignment, 2s.)
3. Implements and Machinery (Agricultural), on their own wheels (specially hauled), not exceeding 1 ton, 4s. each.
4. Single articles, exceeding 1 ton, but not exceeding 3 tons, 4s. 6d. per ton.
5. Single articles, exceeding 3 tons, but not exceeding 5 tons, 6s. 6d. per ton.
6. Single articles, exceeding 5 tons, 8s. 6d. per ton.
7. Carriages, four-wheeled, 5s. each.
8. Carriages, two-wheeled, 4s. each.
9. Cattle, in floats, 3s. 6d. per head (minimum charge, 5s.)
10. Sheep and Pigs, in floats, 1s. per head (minimum charge, 3s. 6d., and maximum charge, 5s. for each float).

The rates charged for carriage do not in any case include collection or delivery.

The carriage of all Live Stock, Implements, and other articles for exhibition at the Show must be prepaid.

## THE PRESIDENT'S CHAMPION MEDALS

A CHAMPION BRONZE MEDAL is given by HIS GRACE THE DUKE OF BUCCLEUCH AND QUEENSBERRY, K.T., President of the Society, for the *best Animal or pen* in each of the following sections:—

| | | |
|---|---|---|
| 1. Shorthorn. | 7. Clydesdale Mares and Fillies. | 13. Shetland Ponies. |
| 2. Aberdeen-Angus. | 8. Draught Geldings. | 14. Blackfaced Sheep. |
| 3. Galloway. | 9. Hunters. | 15. Cheviot. |
| 4. Highland. | 10. Roadsters. | 16. Border Leicester. |
| 5. Ayrshire. | 11. Hackneys. | 17. Shropshire. |
| 6. Clydesdale Stallions. | 12. Ponies. | 18. Half-bred Sheep. |
| | | 19. Swine. |

NOTE.—*Winners at former Shows entered as Extra Stock may compete for these Medals. The award of these Medals is not subject to the Rules as to calving and foaling.*

# CATTLE

### SHORTHORN.

| Class | | Premiums. 1st. £ | 2d. £ | 3d. £ |
|---|---|---|---|---|
| | Tweeddale Gold Medal for Best Shorthorn Bull—£20. | | | |
| 1. | Bull calved before 1st Jan. 1893 . . | 15 | 10 | 5 |
| 2. | Bull calved in 1893 . . . | 15 | 10 | 5 |
| 3. | Bull calved in 1894 . . . | 12 | 8 | 4 |
| | Breeder of Best Bull of any age in the three Classes—The Silver Medal. | | | |
| 4. | Cow of any age . . . . | 12 | 8 | 4 |
| 5. | Heifer calved in 1893 . . . | 10 | 5 | 3 |
| 6. | Heifer calved in 1894 . . . | 10 | 5 | 3 |
| | [1] Best Female of any age in the three Classes—£20. | | | |
| | *President's Medal for best Shorthorn.* | | | |
| | Carry forward | | | £144 |

### ABERDEEN-ANGUS.

[2] Two Silver Cups, each of the value of £50, for the best Bull of any age and for the best Cow of any age (Heifers excluded) in the Aberdeen-Angus cattle classes. These are to be Challenge Cups, and are to be known as the "Ballindalloch Challenge Cups." They are offered under the following conditions: 1. The Directors shall assume charge of the Cups, and shall frame such rules for their safety as they may decide upon. 2. Each Cup shall be held by the winner for one year as a Challenge Cup, and shall become the property of the exhibitor who shall win it five times, not necessarily in succession. 3. The Society shall, at their own expense, cause to be engraved on each Cup each year, the year, the place of the Show, name of successful exhibitor, name and herd-book number of the animal, and name of its breeder. 4. The Society shall award to the breeder of the successful animals a Silver Medal, bearing that he is the breeder of the winner of the "Ballindalloch Challenge Cup." 5. In every other respect the Cups shall be won according to regulations which the Directors may from time to time enact.

[1] Given by the Shorthorn Society. [2] Given by Mr Macpherson Grant of Drumduan.

| | | | | |
|---|---|---|---|---|
| Brought forward ... ... | | | | £144 |
| | Premiums. | | | |
| ABERDEEN-ANGUS—*continued.* | 1st. | 2d. | 3d. | |
| Class | £ | £ | £ | |
| 7. Bull calved before 1st Dec. 1892 | 15 | 10 | 5 | |
| 8. Bull calved on or after 1st Dec. 1892 | 15 | 10 | 5 | |
| 9. Bull calved on or after 1st Dec. 1893 | 12 | 8 | 4 | |
| [1] Champion Cup, value £50, for the best Bull of any age in the three Classes (see above). | | | | |
| Breeder of best Bull of any age in the three Classes—The Silver Medal. | | | | |
| 10. Cow calved before 1st Dec. 1891 | 12 | 8 | 4 | |
| 11.[1] Cow calved on or after 1st Dec. 1891—£12, £8, £4. | | | | |
| [1] Champion Cup, value £50, for the best Cow of any age in the two Classes (see above). | | | | |
| Breeder of best Cow of any age in the two Classes—The Silver Medal. | | | | |
| 12. Heifer calved on or after 1st Dec. 1892 | 10 | 5 | 3 | |
| 13. Heifer calved on or after 1st Dec. 1893 | 10 | 5 | 3 | |
| *President's Medal for best Aberdeen-Angus Animal.* | | | | 144 |
| GALLOWAY. | | | | |
| 14. Bull calved before 1st Jan. 1893 | 15 | 10 | 5 | |
| 15. Bull calved in 1893 | 15 | 10 | 5 | |
| 16. Bull calved in 1894 | 12 | 8 | 4 | |
| [2] Best Bull in the three Classes—Cup, value £10, 10s. | | | | |
| Breeder of Best Bull of any age in the three Classes—The Silver Medal. | | | | |
| 17. Cow of any age | 12 | 8 | 4 | |
| 18. Heifer calved in 1893 | 10 | 5 | 3 | |
| 19. Heifer calved in 1894 | 10 | 5 | 3 | |
| [2] Best Female in the three Classes—Cup, value £10, 10s. | | | | |
| *President's Medal for best Galloway.* | | | | 144 |
| HIGHLAND. | | | | |
| 20. Bull calved before 1st Jan. 1893 | 15 | 10 | 5 | |
| 21. Bull calved in 1893 | 15 | 10 | 5 | |
| 22. Bull calved in 1894 | 12 | 8 | 4 | |
| Breeder of best Bull of any age in the three Classes—The Silver Medal. | | | | |
| 23. Cow of any age | 12 | 8 | 4 | |
| 24. Heifer calved in 1892 | 10 | 5 | 3 | |
| 25. Heifer calved in 1893 | 10 | 5 | 3 | |
| *President's Medal for best Highland Animal.* | | | | 144 |
| Carry forward | | | | £576 |

[1] Given by Mr C. Macpherson Grant of Drumduan.
[2] Given by the Galloway Cattle Society.

Brought forward ... ... £576

| | Premiums. | | | |
|---|---|---|---|---|
| AYRSHIRE. | 1st. | 2d. | 3d. | |
| Class | £ | £ | £ | |
| 26. Bull calved before 1st Jan. 1893 . . | 15 | 10 | 5 | |
| 27. Bull calved in 1893 . . . | 12 | 8 | 4 | |
| 28. Bull calved in 1894 . . . | 8 | 5 | 3 | |
| [1] Best Ayrshire Bull in the three Classes registered, or eligible to be registered, in the Ayrshire Herd-book—Champion Cup, value £50, to be won three times (not necessarily in succession) before becoming the property of the winner. | | | | |
| Breeder of Best Bull of any age in the three Classes—The Silver Medal. | | | | |
| 29. Cow in Milk, any age . . . | 10 | 7 | 3 | |
| 30.[2] Cow in Milk, calved in 1892—Prizes of £10, £7, and £3. | | | | |
| 31. Cow of any age in Calf, or Heifer calved in 1892 in Calf and due to calve within one month of the first day of the Show . | 10 | 7 | 3 | |
| 32. Heifer calved in 1893 . . . | 10 | 5 | 3 | |
| 33. Heifer calved in 1894 . . . | 8 | 5 | 3 | |
| [3] Best Ayrshire Female in the above Classes registered, or eligible to be registered, in the Ayrshire Herd-book—Champion Cup, value £50, to be won three times (not necessarily in succession) before becoming the property of the winner. | | | | 144 |
| *President's Medal for best Ayrshire.* | | | | |
| | | | | £720 |

# HORSES

## FOR AGRICULTURAL PURPOSES.

### CAWDOR CHALLENGE CUP, VALUE 50 GUINEAS, FOR BEST MARE.

*Conditions of Competition.*—1. These Cups are, through the kindness of the Right Honourable the Earl Cawdor, President for the year 1891-92, offered by the Clydesdale Horse Society of Great Britain and Ireland—one for the best Clydesdale Stallion or Entire Colt registered in the Clydesdale Stud-book, and the other for the best Clydesdale Mare or Filly registered in the Clydesdale Stud-book, entered in any of the Draught Horse classes, at the show or shows at which they may be competed for. 2. The Council of the Clydesdale Horse Society shall, at a meeting held not later than the month of August in any year, decide at what show or shows the "Cawdor Challenge Cups" shall be competed for in the year immediately following. 3. Either of these Cups must be won three times by an exhibitor (but not necessarily in consecutive years or with the same animal) before it becomes his absolute property; and immediately after an award has been made, and official notification thereof has been received by the Secretary of the Clydesdale Horse Society from the Secretary of the Society under whose auspices the competition has taken place, the name of the winner, and of the animal

[1] and [3] Given by Ayrshire Cattle Herd-book Society.
[2] Given by Mr Alex. Cross of Knockdon.

with which the Cup has been won, will be engraven on the Cup. 4. The winner of either of the Cawdor Challenge Cups, other than the absolute winner, shall, before delivery thereof is made to him, give security to the Clydesdale Horse Society that he shall surrender the same to the Society and deliver it at the Society's office when called upon to do so. 5. Until the Cup or Cups be won outright, the winner of either Challenge Cup will receive the Clydesdale Horse Society's Silver Medal as a memento of his winning the Cup; and the said Medal shall bear an inscription specifying the show at which, the date on which, and the name of the animal with which the Challenge Cup has been won, as well as the name of the owner. In name of the Council of the Clydesdale Horse Society, and as approved, first, by its Committee, Messrs R. Sinclair-Scott, John M. Martin, and James Park, and finally, by the Right Hon. the Earl Cawdor, its President.

ARCHD. MACNEILAGE, *Secretary.*

For the above Cup all former prize animals at the Society's Shows, now disqualified from competing in the ordinary classes, are permitted to compete. The Clydesdale Horse Society to have the option of photographing the winner for publication in the Clydesdale Stud-book.

| Class | | Premiums. 1st. £ | 2d. £ | 3d. £ | 4th. £ | |
|---|---|---|---|---|---|---|
| 34. | Stallion foaled before 1st Jan. 1892 | 15 | 12 | 8 | 4 | |
| 35. | Entire Colt foaled in 1892 . . | 15 | 12 | 8 | 4 | |
| 36. | Entire Colt foaled in 1893 . . | 15 | 10 | 6 | 3 | |
| 37. | Entire Colt foaled in 1894 . . | 12 | 7 | 4 | 2 | |
| | [1] Best Stallion in the foregoing Classes—Champion Prize of £10. | | | | | |
| | Breeder of Best Male Animal of any age in the four Classes — The Silver Medal. | | | | | |
| | *President's Medal for best Clydesdale Stallion.* | | | | | |
| 38. | Mare of any age, with Foal at foot. | 15 | 10 | 5 | 3 | |
| 39. | Yeld Mare foaled before 1st Jan. 1892 | 10 | 6 | 3 | 2 | |
| 40. | Filly foaled in 1892 . . | 10 | 6 | 3 | 2 | |
| 41. | Filly foaled in 1893 . . | 10 | 6 | 3 | 2 | |
| 42. | Filly foaled in 1894 . . | 10 | 6 | 3 | 2 | |
| | Best Mare or Filly registered in the Clydesdale Stud-book — Cawdor Challenge Cup, value 50 Guineas (see p. 72). | | | | | 254 |
| | *President's Medal for best Clydesdale Mare or Filly.* | | | | | |

| DRAUGHT GELDINGS. | | 1st. | 2d. | 3d. | |
|---|---|---|---|---|---|
| 43. | Draught Gelding foaled before 1st Jan. 1892 . . . | 8 | 4 | 2 | |
| 44.[2] | Draught Gelding foaled in 1892— £5, £3, £2. | | | | |
| 45.[2] | Draught Gelding foaled in 1893— £5, £3, £2. | | | | 14 |
| | *President's Medal for best Draught Gelding.* | | | | |
| | | Carry forward | | | £268 |

[1] Given by Mr James Lockhart, Mains of Airies. [2] Given by Mr Maxwell of Munches.

No animal is allowed to compete in more than one Class, except in the Jumping and Driving Competitions.

Brought forward ... ... £268

| | Premiums. 1st. | 2d. | 3d. | |
|---|---|---|---|---|
| ROAD OR FIELD. | | | | |
| Class | £ | £ | £ | |
| 46. Brood Mare, suitable for breeding hunters, with foal at foot—*in hand* | 10 | 5 | 3 | |
| 47. Hunter, Mare or Gelding, foaled before 1st Jan. 1892, able to carry over 14 stone—*in saddle* . | 12 | 6 | 3 | |
| 48. Hunter, Mare or Gelding, foaled before 1st Jan. 1892, able to carry from 12 to 14 stone—*in saddle* . | 8 | 4 | 2 | |
| 49. Mare or Gelding for field, foaled in 1892—*in hand* . . . | 6 | 4 | 2 | |
| 50. Mare or Gelding for field, foaled in 1893—*in hand* . . . | 6 | 4 | 2 | |
| *President's Medal for best Hunter.* | | | | |
| 51. Roadster, Mare or Gelding, foaled before 1st Jan. 1892, 15 hands and upwards—*in saddle* . | 8 | 4 | 2 | |
| 52. Roadster, Mare or Gelding, foaled before 1st Jan. 1892, 14.2, and under 15 hands—*in saddle* . | 8 | 4 | 2 | |
| *President's Medal for best Roadster* | | | | |
| 53 Colt, Gelding, or Filly, foaled in 1894, the produce of thorough-bred Stallions, out of Mares of any breed,—Five Prizes[1]—£10, £7, £5, £2, £1. | ——— | | | 105 |

HACKNEYS.

(*All to be shown in hand.*)

| | | | | |
|---|---|---|---|---|
| 54 Stallion, any age, over 14.2 hands . | 10 | 5 | 2 | |
| 55. Brood Mare, 15 hands and upwards, with Foal at foot, or to foal this season to a registered Sire . | 10 | 5 | 2 | |
| 56. Brood Mare, under 15 hands, with Foal at foot, or to foal this season to a registered Sire . . | 8 | 4 | 2 | |
| All animals entered in Classes 54, 55, and 56 must be registered in the Hackney Stud-book. | | | | |
| 57. Filly, foaled in 1892 . . | 6 | 4 | 2 | |
| 58. Filly, foaled in 1893 . . | 6 | 4 | 2 | |
| 59. Filly, foaled in 1894 . . | 6 | 4 | 2 | |
| All animals entered in Classes 57, 58, and 59 must be got by registered Hackney Sires. | ——— | | | 84 |

Carry forward £457

[1] Given by Mr Gilmour of Montrave.

No animal is allowed to compete in more than one Class, except in the Jumping and Driving Competitions.

| Class | | Premiums. 1st. £ | 2d. £ | 3d. £ | |
|---|---|---|---|---|---|
| | Brought forward ... ... | | | | £457 |
| | HACKNEYS—*continued.* | | | | |
| 60. | Entire Colt, foaled in 1893, Registered in Hackney Stud-book . | 6 | 4 | 2 | |
| 61. | Entire Colt, foaled in 1894, eligible for entry in Hackney Stud-book | 6 | 4 | 2 | |
| | [1] Prize of £10 and Bronze Medal by Hackney Horse Society for best Mare or Filly in Hackney or Pony Classes. | | | | 24 |
| | *President's Medal for best Hackney.* | | | | |
| | The Scotch Committee of the Hackney Horse Society gives £54 towards the above Prizes for Hackneys. | | | | |
| | DRIVING COMPETITIONS. | | | | |
| 62. | Best Turn-out of single Horse, Harness, and Trap, to be driven in the ring, 15 hands and upwards . | 8 | 4 | 2 | |
| 63. | Best Turn-out of single Horse, Harness, and Trap, to be driven in the ring, under 15 hands . | 8 | 4 | 2 | |
| | | | | | 28 |
| | PONIES. | | | | |
| 64. | Stallion, over 12, not exceeding 14.2 hands . . . . | 4 | 2 | 1 | |
| 65. | Mare or Gelding, between 13 and 14½ hands . . . | 4 | 2 | 1 | |
| 66. | Mare or Gelding, between 12 & 13 hands | 4 | 2 | 1 | |
| 67. | Stallion, under 12 hands . . | 4 | 2 | 1 | |
| 68. | Mare or Gelding, under 12 hands . | 4 | 2 | 1 | |
| | *President's Medal for best Pony.* | | | | 35 |
| | SHETLAND PONIES. | | | | |
| 69. | Stallion, not exceeding 10½ hands, foaled before 1st Jan. 1892 . | 4 | 2 | 1 | |
| 70. | Mare, not exceeding 10½ hands, with foal at foot . . . | 4 | 2 | 1 | |
| 71. | Mare or Gelding, 10½ hands, foaled before 1st Jan. 1892 . . | 4 | 2 | 1 | |
| | *President's Medal for best Shetland Pony.* | | | | 21 |
| | | | | | £565 |

[1] A Mare 6 years old or more must have had a living foal. Winners of the Hackney Society's Medals in 1895, except at the London and Royal English Shows, excluded. The winner must be entered or accepted for entry in Hackney Stud-book, and certified free from hereditary disease.

No animal is allowed to compete in more than one Class, except in the Jumping and Driving Competitions.

## JUMPING COMPETITIONS—*See page* 78.

No animal is allowed to compete in more than one Class, except in the Jumping and Driving Competitions.

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## SHEEP

| BLACKFACED. | Premiums. 1st. | 2d. | 3d. | |
|---|---|---|---|---|
| Class | £ | £ | £ | |
| 72. Tup three shear or upwards | 10 | 5 | 3 | |
| 73. Tup two shear | 10 | 5 | 3 | |
| 74. Shearling Tup | 10 | 5 | 3 | |
| 75. [1] Five Shearling Tups, bred and fed by Exhibitor,—Three Prizes—£15, £10, and £5. | | | | |
| [2] Best Blackfaced Shearling Tup in the foregoing Classes—Champion Prize of £10. | | | | |
| 76. Three Ewes above one shear, with their Lambs at foot | 8 | 4 | 2 | |
| 77. Three Shearling Ewes or Gimmers | 8 | 4 | 2 | |
| [3] Best Pen of Blackfaced Ewes or Gimmers in the foregoing Classes —Champion Prize of £10. | | | | £82 |
| *President's Medal for best pen of Blackfaced Sheep.* | | | | |
| CHEVIOT. | | | | |
| 78. Tup above one shear | 10 | 5 | 3 | |
| 79. Shearling Tup | 10 | 5 | 3 | |
| 80. Three Ewes above one shear, with their Lambs at foot | 8 | 4 | 2 | |
| 81. Three Shearling Ewes or Gimmers | 8 | 4 | 2 | |
| *President's Medal for best pen of Cheviot Sheep.* | | | | 64 |
| BORDER LEICESTER. | | | | |
| 82. Tup above one shear | 10 | 5 | 3 | |
| 83. Shearling Tup | 10 | 5 | 3 | |
| 84. Three Ewes above one shear | 8 | 4 | 2 | |
| 85. Three Shearling Ewes or Gimmers | 8 | 4 | 2 | |
| *President's Medal for best pen of Border Leicesters.* | | | | 64 |
| Carry forward | | | | £210 |

[1] Given by Mr Howatson of Glenbuck. Animals competing for these Prizes must be entered exclusively in Class 75; they cannot be drawn from Class 74.
[2] Given by Mr Howatson of Glenbuck.
[3] Given by Sir T. D. Gibson Carmichael, Bart.

| | Premiums. 1st. £ | 2d. £ | 3d. £ | |
|---|---|---|---|---|
| Brought forward ... ... | | | | £210 |
| **SHROPSHIRE.** | | | | |
| Class | | | | |
| 86. Tup above one shear . . . | 6 | 4 | 2 | |
| 87. Shearling Tup . . . | 6 | 4 | 2 | |
| 88. Three Ewes above one shear . . | 5 | 3 | 2 | |
| 89. Three Shearling Ewes or Gimmers . | 5 | 3 | 2 | |
| *President's Medal for best pen of Shropshires.* | | | | 44 |
| **HALF-BRED.** | | | | |
| 90. Tup above one shear . . . | 6 | 4 | 2 | |
| 91. Shearling Tup . . . | 6 | 4 | 2 | |
| 92. Three Ewes above one shear . . | 5 | 3 | 2 | |
| 93. Three Shearling Ewes or Gimmers . | 5 | 3 | 2 | |
| *President's Medal for best pen of Half-bred Sheep.* | | | | 44 |
| **EXTRA SECTIONS.** | | | | |
| 94. Three Blackfaced Wethers, one shear | 4 | 2 | — | |
| 95. Three Cheviot Wethers, one shear . | 4 | 2 | — | |
| 96. Five Fat Lambs, any breed or cross . | 4 | 2 | — | |
| [1] Best Pens of Cross-bred Lambs in Class 96 got by Shropshire Tups —Three Prizes—£5, £3, £2. | | | | 18 |
| | | | | £316 |

# SWINE

| | Premiums. 1st. £ | 2d. £ | |
|---|---|---|---|
| **LARGE WHITE BREED.** | | | |
| Class | | | |
| 97. Boar . . . . . . | 4 | 2 | |
| 98. Sow . . . . . . | 4 | 2 | |
| 99. Three Pigs, not above 8 months old . | 4 | 2 | |
| | | | 18 |
| **WHITE BREED OTHER THAN LARGE.** | | | |
| 100. Boar . . . . . . | 4 | 2 | |
| 101. Sow . . . . . . | 4 | 2 | |
| 102. Three Pigs, not above 8 months old . | 4 | 2 | |
| | | | 18 |
| **BERKSHIRE.** | | | |
| 103. Boar . . . . . . | 4 | 2 | |
| 104. Sow . . . . . . | 4 | 2 | |
| 105. Three Pigs, not above 8 months old . | 4 | 2 | |
| *President's Medal for best pen of Swine.* | | | 18 |
| | | | £54 |

[1] Given by Scotch Breeders of Shropshire Sheep, per Mr David Buttar.

# JUMPING COMPETITIONS

## SPECIAL REGULATIONS.

(*See also the Regulations on pages* 59 *to* 69.)

1. Jumping Competitions will take place on the afternoons of Wednesday, Thursday, and Friday, the 24th, 25th, and 26th July.
2. *Entries* for each day's Competitions will close at the Secretary's Office in the Showyard at 6 P.M. on the preceding day.
3. *Entry Fees.*—For classes for Horses—Wednesday, £1; Thursday and Friday, 10s. for each class. Pony classes—Wednesday, 10s.; Thursday and Friday, 5s. for each class.
4. *Accommodation* for jumping horses will be provided as follows:—Covered shed in which to stand during the day free of charge; or, on application to the Secretary not less than seven days before the opening of the Show, stalls or loose-boxes will be provided at a charge (in addition to the Entry Fee) of £1 for a stall, and £1, 10s. for a loose-box, which must be paid along with the Entry Fee at the time of application.
5. Horses entered for jumping only need not enter the Showyard till 10 A.M. on the day of Competition, and may leave the Showyard at 6 P.M. each day.
6. *The Jumps* may consist of Single Hurdle, Gate, Double Hurdle, Wall, and Water Jump, power being reserved by the Society to alter these, as well as the Handicaps, as may be thought desirable.

| Class | 1st. | 2d. | 3d. | |
|---|---|---|---|---|
| **WEDNESDAY.** | £ | £ | £ | |
| 1. Horses—open | 20 | 10 | 5 | |
| 2. Ponies, 14½ hands and under | 5 | 3 | 1 | |
| **THURSDAY.** | | | | |
| 3. Horses, Open Handicap, hurdles and gate being raised 8 inches for the winner of the first prize, and 4 inches for the winner of the second prize in Class 1 | 10 | 6 | 3 | |
| 4. Ponies, 14½ hands or under, Handicap, hurdles and gate being raised 4 inches for first prize winner in Class 2 | 5 | 3 | 1 | |
| **FRIDAY.** | | | | |
| 5. Horses, Open Handicap, hurdles and gate being raised 8 inches for the winner of the first prize, and 4 inches for the winner of the second prize in either of Classes 1 or 3—4 inches extra for the winner of the two first prizes in Classes 1 and 3 | 10 | 6 | 3 | |
| 6. Ponies, 14½ hands or under, Handicap, hurdles and gate being raised 4 inches for the winner of the first prize in Class 2 or in Class 4, and 8 inches for winner of the first prize in both these Classes | 3 | 2 | 1 | |
| | | | | £97 |

[1] Champion Prize of £10 for most points in Prizes for Jumping by one Exhibitor with one or more horses in above Classes—First Prize to count three points; Second Prize, two points; and Third Prize, one point. The money to be evenly divided in the event of a tie.

[1] By various Contributors.

## EXTRA STOCK

Animals not included in the Classes for Competition may be exhibited as Extra Stock, and may receive Honorary Mention, as follows :—Very highly commended, Highly commended, or Commended.

Animals entered as Extra Stock are eligible to compete for the President's Champion Medals.

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## POULTRY

*First Premium* — ONE SOVEREIGN ; *Second Premium* — TEN SHILLINGS ; one Commended Ticket—in all the Sections of Poultry.

Aged Birds must have been hatched previous to, and Cockerels and Pullets in, 1895.

| | Class | Class |
|---|---|---|
| DORKING—*Silver Grey* . | 1. Cock | 2. Hen |
| | 3. Cockerel | 4. Pullet |
| DORKING—*Coloured* . | 5. Cock | 6. Hen |
| | 7. Cockerel | 8. Pullet |
| COCHIN-CHINA . . | 9. Cock | 10. Hen |
| | 11. Cockerel | 12. Pullet |
| BRAHMAPOOTRA . . | 13. Cock | 14. Hen |
| | 15. Cockerel | 16. Pullet |
| SCOTCH GREY . . | 17. Cock | 18. Hen |
| | 19. Cockerel | 20. Pullet |
| HAMBURG . . | 21. Cock | 22. Hen |
| | 23. Cockerel | 24. Pullet |
| PLYMOUTH ROCK . | 25. Cock | 26. Hen |
| | 27. Cockerel | 28. Pullet |
| MINORCA . . . | 29. Cock | 30. Hen |
| | 31. Cockerel | 32. Pullet |
| LEGHORN . . . | 33. Cock | 34. Hen |
| | 35. Cockerel | 36. Pullet |
| LANGSHAN . . | 37. Cock | 38. Hen |
| | 39. Cockerel | 40. Pullet |
| WYANDOTTE . . | 41. Cock | 42. Hen |
| | 43. Cockerel | 44. Pullet |
| ANY OTHER PURE BREED | 45. Cock | 46. Hen |
| | 47. Cockerel | 48. Pullet |
| GAME—*Black or Brown Reds* | 49. Cock | 50. Hen |
| | 51. Cockerel | 52. Pullet |
| GAME — *Any other Pure Breed* | 53. Cock | 54. Hen |
| | 55. Cockerel | 56. Pullet |
| BANTAMS—*Any Pure Breed* | 57. Cock | 58. Hen |
| | 59. Cockerel | 60. Pullet |
| DUCKS—*White Aylesbury* | 61. Drake | 62. Duck |
| | 63. Drake (Young) | 64. Duckling |
| DUCKS—*Rouen* . . | 65. Drake | 66. Duck |
| | 67. Drake (Young) | 68. Duckling |

| | Class | Class |
|---|---|---|
| DUCKS—*Any other Pure Breed* | 69. Drake | 70. Duck |
| | 71. Drake (Young) | 72. Duckling |
| TURKEYS—*Any Pure Breed* | 73. Cock | 74. Hen |
| | 75. Cock (Poult) | 76. Hen (Poult |
| GEESE—*Any Pure Breed* . | 77. Gander | 78. Goose |
| | 79. Gander (Young) | 80. Gosling |

Amount of Poultry Premiums, £120.

## DAIRY PRODUCE

| Class | Premiums. 1st. £ | 2d. £ | 3d. £ | 4th £ | |
|---|---|---|---|---|---|
| 1. Cured Butter, not less than 7 lb. | 4 | 2 | 1 | | |
| 2. Powdered Butter, not less than 7 lb. | 4 | 2 | 1 | | |
| 3. Fresh Butter, three 1-lb. rolls . | 4 | 2 | 1 | | |
| 4. Cheddar Cheese, 56 lb. and upwards,—Seven Prizes—£12, £9, £7, £5, £4, £2, £1. | | | | | |
| 5. Sweet-milk Cheese, flat shape, white in colour, made according to the Dunlop or other method,—Four Prizes—£6, £4, £2, £1. | | | | | £74 |

No Exhibitor to show more than one lot in any Class.

## HORSE-SHOEING

(*Prizes given by Sir James H. Gibson-Craig, Bart.*)
Open to Shoeing-Smiths from any part of the United Kingdom.
Class I. DRAUGHT-HORSES.—*Thursday*, at 10 A.M.
Prizes: 1st, £3; 2d, £2; 3d, £1.
Class II. ROADSTERS.—*Friday*, at 10 A.M.
Prizes: 1st, £3; 2d, £2; 3d, £1.

1. Entries must be made with the SECRETARY not later than 17th June. Entry Fee, 5s. for each Competition. Entry Forms may be had on application.
2. Each Competitor will be required to make, take off, and put on one or two shoes, as may be directed by the Judge.

[*Iron of the usual sizes* will be supplied by the Society. The holes in the anvils will be 1¼ square and ⅝ round.]

3. The time occupied by each Competitor will be taken by the attending Member and given to the Judge if he is unable to decide otherwise.
4. The competitor must bring his own tools and nails, and provide his own striker, if he requires one. The Society will provide horses, forge, anvil, iron, and fuel.
5. Any Competitor who does not attend at the Horse-Shoeing Shed and answer to his name at 10 A.M. on the day on which he is entered for competition, will be debarred from competing.
6. The Competitor and his striker will be admitted to the Yard free of charge on the day of Competition on presentation of tickets which will be sent to the Competitor for the purpose.

## EXHIBITION OF BINDERS

An exhibition of Binders at work will be held in the district of the Show during the Harvest of 1895. Entries close July 6. Entry Fee, £1. Particulars will be had on application to the Secretary.

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## TRIAL OF TURNIP-LIFTERS

A competitive trial of Turnip-Lifters will be held in the district of the Show at a time and place to be afterwards fixed,—First Prize, £10; Second Prize, £5. Entries close July 6. Entry Fee, £1.

## ABSTRACT OF PREMIUMS.

[19 Champion Medals given by The Duke of Buccleuch.]

### Given by the Society.

| | | | |
|---|---|---|---|
| 1. Cattle | £720 | 0 | 0 |
| 2. Horses | 565 | 0 | 0 |
| 3. Jumping | 97 | 0 | 0 |
| 4. Sheep | 316 | 0 | 0 |
| 5. Swine | 54 | 0 | 0 |
| 6. Poultry | 120 | 0 | 0 |
| 7. Dairy Produce | 74 | 0 | 0 |
| 8. Medals to Breeders, &c. | 6 | 0 | 0 |
| | £1952 | 0 | 0 |
| *Less*—Amount contributed by the Scotch Committee of the Hackney Horse Society, as below | 54 | 0 | 0 |
| | £1898 | 0 | 0 |

### Given by

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. The Shorthorn Society | £20 | 0 | 0 | | | |
| 2. Mr C. Macpherson Grant of Drumduan,—Cups and Prizes | 124 | 0 | 0 | | | |
| 3. Galloway Cattle Society | 21 | 0 | 0 | | | |
| 4. Ayrshire Cattle Herd-book Society | 100 | 0 | 0 | | | |
| 5. Mr Alex. Cross of Knockdon | 20 | 0 | 0 | | | |
| 6. Mr Lockhart, Mains of Airies | 10 | 0 | 0 | | | |
| 7. Cawdor Cup | 52 | 10 | 0 | | | |
| 8. Mr Maxwell of Munches | 20 | 0 | 0 | | | |
| 9. Mr Gilmour of Montrave | 25 | 0 | 0 | | | |
| 10. The Scotch Committee of the Hackney Horse Society | 54 | 0 | 0 | | | |
| 11. Hackney Horse Society | 10 | 0 | 0 | | | |
| 12. Mr Howatson of Glenbuck | 40 | 0 | 0 | | | |
| 13. Sir T. D. Gibson Carmichael, Bart. | 10 | 0 | 0 | | | |
| 14. Scotch Breeders of Shropshire Sheep | 10 | 0 | 0 | | | |
| 15. Tweeddale Gold Medal | 20 | 0 | 0 | | | |
| 16. Sir James H. Gibson-Craig, Bart. | 12 | 0 | 0 | | | |
| 17. Various Contributors (for Jumping) | 10 | 0 | 0 | | | |
| | | | | 558 | 10 | 0 |
| | | | | £2456 | 10 | 0 |

JAMES MACDONALD, *Secretary*.

3 George IV. Bridge,
Edinburgh, *March* 1895.

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**The General Show of Stock and Implements will be held at Perth in 1896.**

# APPENDIX (B)

# LIST OF MEMBERS

OF

# THE HIGHLAND AND AGRICULTURAL SOCIETY OF SCOTLAND

ARRANGED ACCORDING TO COUNTIES AND SHOW DISTRICTS

1895

By the Charter of 1834 the Society consists of two classes, Ordinary and Honorary or Corresponding Members. The number of Honorary or Corresponding Members resident in the United Kingdom must not exceed twenty, but with power to the Society to elect as Honorary Associates persons resident abroad, not subjects of her Majesty, who may have been benefactors to the Society, or who are distinguished for their skill in Art or Science, provided that the number of such Foreign Associates shall not exceed twenty.

By a Bye-law passed in 1873, with reference to the Supplementary Charter of 1856, successful Candidates for the Society's Agricultural Diploma are thereby eligible to be elected free Life Members of the Society.

Candidates for admission to the Society must be proposed by a Member, and are elected at the half-yearly General Meetings in January, and June or July, but it is not necessary that the proposer should attend the meeting.

The Ordinary Subscription is £1, 3s. 6d. annually, which may be redeemed by one payment, varying according to the number of previous annual payments, from £7, 1s. to £12, 12s. Proprietors farming the whole of their own lands, whose Rental on the Valuation Roll does not exceed £500 per annum, and all Tenant Farmers, Secretaries or Treasurers of Local Agricultural Associations, Factors Resident on Estates, Land Stewards, Foresters, Agricultural Implement Makers, and Veterinary Surgeons, none of them being also owners of land to an extent exceeding £500 per annum, are admitted on a subscription of 10s. annually, which may be redeemed by one payment, varying according to the number of previous annual payments, from £3 to £5, 5s. Subscription payable on election, and afterwards annually in January.

According to the Charter, "Any person elected an Ordinary Member of the Society who shall not have objected to his election, on the same being intimated to him by the Secretary, shall not be entitled to resign or withdraw his name as a Member of the Society, unless he shall have paid up his Life Subscription, or shall have previously settled and paid in Annual Contributions a sum equal to that fixed by the Society at the time of his election, to be paid by Members as the purchase of a Life Subscription in lieu and in redemption of the Annual Payments." The Life Subscription for a Member paying £1, 3s. 6d. is £12, 12s., and for a Member paying 10s., £5, 5s.

Members having Candidates to propose are requested to state whether the Candidate should be on the £1, 3s. 6d. or 10s. list.

Members of the Society receive the 'Transactions' free on application, and are entitled to consult the Chemist and Botanist at reduced rates—to apply for District Premiums—to report Ploughing Matches for the Medal—to free admission to the Show-Yard, and to exhibit Stock and Implements at reduced rates. Firms are not admitted as Members, but if one partner of a firm becomes a Member, the firm is allowed to exhibit at Members' rates.

Members having Candidates to propose are requested to send their names to James Macdonald, Esq., 3 George IV. Bridge, Edinburgh.

By a Resolution of the Directors, 2d February 1887, the list of Members, arranged according to Counties, has been so made up that no Member shall vote in more than one Show District for the nomination of Directors. Members finding any mistakes are requested to report the same to James Macdonald, Esq., 3 George IV. Bridge, Edinburgh.

The following is the List of Counties constituting the Show Districts:—

# LIST OF MEMBERS

ARRANGED ACCORDING TO COUNTIES AND SHOW DISTRICTS.

*The Members marked * have been Presidents, and † Vice-Presidents.*

| | Admitted |
|---|---|
| Her Most Gracious Majesty THE QUEEN. | 1872 |
| * His Royal Highness The PRINCE OF WALES. | 1873 |

## 1.—GLASGOW DISTRICT.

EMBRACING THE

COUNTIES OF ARGYLL, AYR, BUTE, LANARK, AND RENFREW.

### ARGYLL.

Admitted
1881 Allan, Alex., of Aros, Tobermory
1875 Allan, Robt., Glenmore, Lochgilphead
1852 Allan, T. W. M., of Glenfeochan, Oban
1889 Anderson, Wm. D., Ardsheal, Ballachulish
1889 Andrew, David, Knockstaple, Campbeltown
1844*†Argyll, The Duke of, K.G., Inveraray Castle, Inveraray
1868 Berry, Walter, Glenstriven, Toward
1882 Black, Donald, junior, Clachan, Lochfynehead, Inveraray
1891 Blair, John Simpson, Melfort, Kilmelfort
1884 Boyd, Wm., Killundine, Oban
1873 Brown, Alexander, Banker, Oban
1875 Bruce, Henry, of Ederline, Lochgilphead
1881 Buchanan, Dr Alexander, Tiree, Tobermory
1881 Buchanan, Angus, Druimnatoran, Strontian
1858 Buchanan, Dun., Auchinbreck, Colintraive
1893 Bulk, Herbert, Keil House, Ballachulish
1889 Cameron, Allan Gordon, of Barcaldine Castle, Taynuilt
1871 Cameron, John, Druimvallie, Fort-William
1837 Campbell, Alex., of Achendarroch, Lochgilphead
1891 Campbell, Alex. E., Duiletter, Dalmally
1865 Campbell, Lt.-Col., of South Hall, Colintraive
1889 Campbell, Alex. James Henry, of Dunstaffnage, Oban
1894 Campbell, Colin George Pelham, Stonefield, Tarbert
1875 Campbell, Capt. D., of Invernell and Ross, Ardrishaig

Admitted
1882 Campbell, Edward P., Captain, 42d Highlanders, South Hall, Colintraive
1885 Campbell, Lt.-Col. H. Burnley, of Ballimore, Tigh-na-bruaich
1883 Campbell, James, of Jura, Greenock
1888 Campbell, James, Shanvallie, Ledaig
1877 Campbell, James, Succoth Villa, Lochgilphead
1874 Campbell, John, of Kilberry, Tarbert
1877 Campbell, John, Glenforsa, Aros, Mull
1894 Campbell, John, Ardifuir, Kilmartin, Lochgilphead
1890 Campbell, Robt. C. Graham, of Shirvan, Lochead Lodge, Ardrishaig
1877 Clark, Andrew, Islay
1869 Clark, Archd., Bencorrum, Dunoon
1858 Clark, Archibald, Inverchapple, Kilmun
1893 Clark, Francis Wm., of Ulva, Aros, N.B.
1867 Clark, Lachlan, Tangy, Campbeltown
1889 Clark, Robert, Skerbolin, Campbeltown
1872 Coltart, Robert, Achateny, Ardnamurchan
1894 Colville, Robert, Glensaddell, Campbeltown
1885 Corson, Thomas, Auction Mart, Oban
1882 Craig, Hugh, Ardoran, Oban
1891 Craig, William, Carsaig, Mull, Oban
1891 Craig, William, Tiroran, Mull
1884 Crerar, Peter C., Brackley, Dalmally
1889 Cunningham, Robert, Kilkivan, Campbeltown
1867 Dickie, Robt., Killeonan, Campbeltown
1878 Duncan, Alex., Duart, Auchnacraig, Mull
1881 Duncan, R., Royal Hotel, Tigh-na-bruaich
1884 Elliot, Walter, Ardtornish, Oban
1893 Ferguson, Archd., Lochaline, Morven
1885 Finlay, C. Campbell, of Castle Toward, Greenock

Admitted
1870 Finlay, Kirkman, of Dunlossit, Islay
1870 Fletcher, B. J. C., Dunans, Colintraive
1874 Forsyth, James N. M., of Quinish, Tobermory
1884 Fraser, Duncan, Hotel, Dalmally
1867 Gardyne, Col. C. G., of Glenforsa, Mull
1889 Gemmell, John, Dalrioch, Campbeltown
1875 Gillespie, John, Temperance Hotel, Oban
1891 Gillies, John, Barnacarrie, Kilninver, Oban
1891 Graham, Archd. W., Erray, Tobermory
1889 Graham, Robt. C., of Skipness, Whitehouse
1888 Graham, William, of North Erines, Tarbert (6 Royal Crescent, Glasgow)
1872 Grant, A., Cuil House, Inveraray
1891 Greenbank, Jonathan C., Gigha, Greenock
1894 Greig, James, Chiskan, Campbeltown
1873 Hall, Allan, Degnish, Ardmaddy, Easdale, Oban
1875 Hall, Jas. M., Killean House, Tayinloan
1888 Hamilton, George, Crear, Tarbert, Lochfyne
1865 Hay, C., Ardbeg, Islay
1853 Hosack, William, Oban
1889 Hunter, James, Machribeg, Campbeltown
1857 Hunter, Wm., Lilybank, Campbeltown
1894 Inglis, George Erskine, Machrahanish Estate Office, Campbeltown
1889 Kinloch, Charles, Ballymeanach, Portsonachan
1850 Lamont, James, of Knockdow, Greenock
1875 Lloyd, T., of Minard Castle, Inveraray
1869†Lorne, The Marquis of, K.T.
1883 Lothian, James, Campbeltown
1862 Macarthur, John, Banker, Inveraray
1861 M'Callum, John, Fairfield, Kirn
1879 M'Coll, Duncan, Clachan House, Lismore, Oban.
1881 Macdiarmid, H., Island House, Tiree, Oban
1882 Macdiarmid, Robert, Castles, Lochawe
1874 Macdonald, Alex., Nether Largie, Lochgilphead
1893 Macdonald, J. Ronald M., Largie Castle, Tayinloan
1889 Macdougall, Allan, Maam, Inveraray
1872 M'Dougall, Col. Chas. A., of Dunollie, Oban
1893 M'Dougall, Duncan C., Ashens, Tarbert, Lochfyne
1882 MacDougall, James Patten, Gallanach, Oban
1892 M'Dougall, Major S., of Lunga, Daill House, Lochgilphead
1894 Macfarlane, Donald, Coilessan, Arrochar
1873 Macfarlane, Lewis, Invermay, Lochgoilhead
1863 M'Gibbon, David, Ardnacraig, Campbeltown
1870 MacGregor, Donald, of Ardgartan, Glencroe (Royal Hotel, Edinburgh)
1883 MacGregor, Donald, Solicitor, Oban
1893 M'Intyre, John Alexander, Ichrachan, Taynuilt, Oban
1877 Mackay, A. F., Carskey House, Campbeltown
1892 M'Kechnie, Dugald, of Tenga, Oban (60 Northumberland Street, Edinburgh)
1869 MacKechnie, Jas., Blarcreen House, Taynuilt
1878 Mackellar, John, Crossaig, Tarbert
1878 Mackellar, Peter, Crossaig, Tarbert
1872 Mackenzie, John, of Knipoch, Oban
1891 Mackenzie, J. H. Munro, of Mornish, Tobermory
1857 M'Kerral, A., Brunerican, Campbeltown
1874 M'Lachlan, D., Lochgilphead
1886 Maclachlan, Jn.,of Maclachlan,Inveraray (12 Abercromby Place, Edinburgh)
1870 Maclaine, M. G., of Lochbuie, Oban
1888 M'Laren, Dun., Banker, Tarbert, Lochfyne
1875 M'Latchie, W., Ballygreggan, Campbeltown
1875 M'Lean, A. J., of Pennycross, Oban
1849 Macleod, John N., of Kintarbert, Glensaddell, Campbeltown
1894 M'Nair, Archibald, Moy, Campbeltown
1848 Macneal, H., of Ugadale, Campbeltown
1860 M'Neill, Maj.-Gen. Sir J. C., of Colonsay, V.C., K.C.M.G., K.C.B.
1876 M'Nicol, John, Achandarroch, Ballachulish
1882 M'Phail, John, Scallasdale, Mull
1891 Macpherson, Colin D., Corpach, Fort William
1888 Macpherson, James, Maam, Inveraray
1891 M'Vean, Colin A., Kilfinichen, Pennyghael, Mull
1874 Masson, John, Tobermory
1881 Maxwell, Wm., Baraskomel, Campbeltown
1891 Meikle, R. A., Ri-Cruin, Lochgilphead
1894 Melles, Joseph, Gruline Aros, Isle of Mull
1874 Menzies, John, the Hotel, Banavie
1861 Mercer, John, Ardnadam, Sandbank
1889 Mitchell, Archibald, Clockiel, Campbeltown
1889 Mitchell, James B., Aros, Campbeltown
1855 Morrison, Charles, of Islay, Bridgend
1893 Mundell, James, Achnacarnan, Tarbert, Lochfyne
1877 Munro, D. H. C., of Kenlochlaich, Appin
1888 Munro, John, Ironmonger, Oban
1888 Nicolson, Neil, Auchgoyle, Tigh-na-bruaich
1887 Orde, Colin Campbell, Kilmory, Lochgilphead
1858 Orde, Sir John W. P. Campbell, of Kilmory, Bart., Lochgilphead
1889 Ralston, Gav., Kilmichael, Campbeltown
1882 Reid, Peter, Port Ellen, Islay—*Free Life Member*
1892 Robertson, Alexander, Chemist, Oban
1884 Robertson, John, Craig Farm, Dalmally
1891 Routledge, Joseph, Annat, Fort William
1893 Scarlett, W. J. Yorke, Gigha
1891 Shairp, Alex., Land Agent and Architect, Oban
1884 Shankland, Wm., Killicheran, Lismore
1875 Sinclair, John, Fanans, Taynuilt
1884 Smith, T. V., of Ardtornish, Oban
1881 Smith, W. Anderson, Ledaig
1879 Stewart, Rev. A. M., Inverchaolain, Greenock
1894 Stewart, Alexander, Darlochan, Campbeltown
1863 Stewart, Com. D., R.N., Knockrioch, Campbeltown
1881 Stewart, John Lorne, of Coll, Oban
1871 Stewart, Capt. J. C., of Fasnacloich, Ledaig
1858 Stewart, Robt., of Kinlochmoidart, Salen (4 Moray Place, Edinburgh)
1892 Stuart, Mrs E., Dalness, Glenetive, Taynuilt
1889 Sutherland, John D., Oban
1893 Thom, Allan Gilmour, Canna
1891 Thomson, Duncan, Inveryne, Tigh-na-bruaich
1859 Thorburn, David, St Mary's, Tobermory
1870 Tod, James, Rashfield, Kilmun
1875 Turner, A., Kilchamaig, Whitehouse, Kintyre
1853 Turner, D., Corachaive, Sandbank

Admitted
1893 Veitch, John, jun., Cretsheugan, Tarbert
1876 Whyte, D. C., Ballymore, Sandbank
1863 Wyllie, James, Factor, Inveraray
1887 Young, William, Drum, Campbeltown

## AYR.

1882 Ailsa, The Marquis of, Culzean Castle, Maybole
1867 Allan, Andrew, North Kirkland, Dalry, Ayr
1895 Allan, James, Munnoch, Dalry, Ayr
1882 Alston, George, Loudoun Hill, Darvel
1890 Alston, H. R., Swindrige Muir, Dalry
1893 Bone, David, Auchencloich, Sorn, Galston
1882 Bone, William, Shalloch Park, Girvan
1893 Borland, John Kennedy, North Balloch, Girvan—*Free Life Member*
1865 Boyd, Col. J. Hay, of Townend, Symington, Kilmarnock
1890 Brisbane, C. T., of Brisbane, Largs
1866 Brown, David, Banker, Maybole
1870 Bruges, Edward C., Dalgig, New Cumnock
1889 Caldwell, John, Bogside, Dundonald
1891 Campbell, James Archibald, of Craigie, Ayr
1887 Campbell, W. K. H., of Nether Place, Mauchline
1857 Clark, William, Shawhill, Monkton
1891 Clark, W. K., Currah Farm, Girvan
1877 Cochrane, James, Minnieveay, Dalmellington
1882 Cochrane, Hon. Thomas, Largs
1865 Crawford, J., Milnstonford, W. Kilbride
1880 Cuninghame, Sir W. M., of Corsehill, Bart., Glenmore House, Maybole
1859 Cunningham, W. C. S., of Caprington, Kilmarnock
1857 Deans, J. Y., of Kirkstyle, Kilmarnock
1889 Dempster, Jas. R., yr. of Ladyton, Galston
1890 Drummond, Hugh, Craighead of Rodinghead, Mauchline
1893 Duke, Guy, Braehead Office, Kilmarnock
1887 Dunlop, And. T. L., Morriston, Maybole —*Free Life Member*
1869 Dunlop, Gabriel, Castle Farm, Stewarton
1875 Dunlop, Quintin, Morriston, Maybole
1889 Dunlop, Wm. Hamilton, of Doonside, Ayr
1880 Fergusson, John Blackburn, Doonholm, Ayr
1854 Fergusson, Right Hon. Sir James, of Kilkerran, Bart., M.P., Maybole
1875 Foulds, A. R., of Clerkland, Stewarton
1891 Fraser, M. P., Blackcraig, New Cumnock
1885 Gemmell, Andrew, Lugton Ridge, Beith
1875 Gemmel, G. C., Upper Whitehaugh, Muirkirk
1875 Gilmour, Alex., Annfield House, Irvine
1875 Gilmour, James, Orcharton, Cumnock
1881 Glasgow, The Earl of, Kelburn, Fairlie
1874 Glasgow, R. B. R., of Montgreenan, Kilwinning
1894 Gray, William, Grougar Bank, Galston
1884 Guthrie, Wm., Crossburn, Troon
1890 Hamilton, Claude, Carbieston, Ayr
1853 Hamilton, Hugh, of Pinmore, Ayr
1865 Hamilton, J., Wallace Bank, Kilmarnock
1839 Hamilton, Lieut.-Col. John, of Sundrum, Ayr
1887 Hamilton, John W., of Cairnhill, Kilmarnock
1889 Hannah, John M., Girvan Mains, Girvan
1878 Hay, J. F. Dalrymple, Dunlop House, Dunlop

Admitted
1874 Henderson, Richard, Portland Estates Office, Kilmarnock—*Free Life Member*
1889 Herron, Thos., Trees, Maybole
1865 Houldsworth, Henry, Carrick House, Ayr
1857 Houldsworth, J. H., Rozella, Ayr
1865 Houldsworth, J. M., Ayr
1857 Houldsworth, Wm., Mount Charles, Ayr
1876 Howatson, W. M. S., Carskeoch, Patna
1865†Howatson, Chas., of Dornel, Glenbuck
1857 Howie, John, Hurlford, Kilmarnock
1894 Howie, M. G., Law Farm, Dreghorn
1889 Howie, Thomas, Monkton, Ayr
1867 Hunter, David, 3 Barns Terrace, Ayr
1894 Hunter, Hugh, Mossbog, Tarbolton
1878 Hunter, Thomas, Implt. Maker, Maybole
1859 Hyndman, Henry C., of Springside, West Kilbride
1877 Inglis, Robert, Loveston House, Girvan
1885 Johnstone, James, Alloway Cottage, Ayr
1870 Kennedy, William, Claremont, Ayr
1874 Kennedy, William, Ayr
1869 Kerr, James, Lochend, Kilbirnie
1882 Kilpatrick, Jas., Craigie Mains, Craigie
1889 King, Robert A., Ayr
1873 Latta, William, Darmalloch, Cumnock
1865 Lindsay, John, Semple House, Stewarton
1880 Littlejohn, James, Genoch, Ayr
1874 M'Connell, Wm., of Knockdolian, Girvan
1879 M'Farlane, Richard, County Club, Ayr
1887 M'Jannet, Archibald C., Irvine
1886 M'Min, Thomas M'C., Craigievar, West Kilbride
1877 Marshall, John, Implt. Maker, Maybole
1875 Martin, Donald T., of Girgenti, Irvine
1886 Middlemas, Wm., Solicitor, Kilmarnock
1882 Montgomerie, Rob., Lessnessock, Ochiltree
1889 Montgomery, John, Meadowhead, West Kilbride
1893 Morton, Alexander, Gowanbank, Darvel
1892 Morton, William, Highbowhill, Newmilns
1889 Murdoch, Alex., Ayr
1884 Niven, Richard, Airlie, Ayr
1870 Oswald, Rich. A., of Auchincruive, Ayr
1888 Paton, Hugh (W. Samson & Co.), Kilmarnock
1881 Pollock, A., Mauchline
1889 Pollock, R. M., Middleton, Ayr
1895 Reid, David H., Attiquin, Maybole
1894 Robertson, Andrew, Holmes Farm, Kilmarnock
1857 Rodger, Hugh, Hillhead, Kilmarnock
1882 Scott, C. W., Hawkhill, Largs
1890 Scott, John, C.B., Everlie, Skelmorlie
1875 Scott, Robert Sinclair, Burnside, Largs
1872 Shaw, Chas. G., Ayr
1893 Shaw, D. W., 17 Wellington Square, Ayr
1893 Shaw, Philip A., Blair, Maybole
1888 Skeoch, Peter, Boydston, Beith
1870 Sloan, John, Alton Albany, Barr, Girvan
1860 Sloan, Wm., Brieryside, Monkton
1889 Smith, Robert, Sheilds, St Quivox, Ayr
1880 Smith, Thomas, The Castle, Maybole
1895 Smith, William, Gateside, Beith
1882 Somervell, James, of Sorn, Mauchline
1887 Somerville, Wm., Hapland Mills, Dunlop
1879 Speir, Robert, Rosebank, Largs
1885 Steel, Alex., Burnhead, Newmilns
1895 Steven, John, Purroch, Hurlford, Kilmarnock
1885 Stevenson, Allan, Architect, Ayr
1888 Stevenson, David, Silverwood, Kilmarnock
1885 Stevenson, David, Auchengate, Troon
1888 Stevenson, John, Balig, Ballantrae
1885 Stewart, James, Blackhouse, Skelmorlie
1858 Stewart, James, Heathfield, Irvine

Admitted
1882 Stuart, A., Muirhouse, Symington, Kilmarnock
1894 Tannahill, Robert D., National Bank Buildings, Kilmarnock
1876 Taylor, H., Kamishill, Hurlford, Kilmarnock
1882 Thornycroft, J. B., Netherplace, Mauchline
1886 Tivendale, William, Burn House, Galston
1891 Todd, Hugh, Harperland, Dundonald
1884 Turner, J. H., Portland Estates Office, Kilmarnock
1867 Vernon, Hon. G. R., Auchans House, Kilmarnock
1887 Wallace, H. R., Cloncaird Castle, Maybole
1875 Wallace, Robert, Auchenbrain, Mauchline
1874 Wardrop, Robert, Garlaff, Cumnock
1868 Weir, W., of Kildonan, Shewalton, Dreghorn
1889 Whyte, Robert, East Raws, Kilmarnock
1882 Willison, Alex., Easterhill, Dalry
1878 Willison, George, Woodbank, Dailly
1858 Wilson, James, Banker, Kilmarnock
1893 Wilson, Robert, Auchincloigh, Ochiltree
1882 Wright, R. P., Downan, Ballantrae—*Free Life Member*
1884 Wyllie, Alex., Holmbyre, Ardrossan
1868 Young, John, jun., Ayr

## BUTE.

1855 Allan, James, Clauchlands, Lamlash
1870 Allan, James, jun., Balnacoole, Shiskine, Arran
1889 Anderson, Francis, Bute Estate Office, Rothesay
1869†Bute, The Marquis of, K.T., Mount Stuart, Rothesay
1889 Dickie, Wm. P., Cranslagvourty, Rothesay
1889 Duncan, Chas., Little Kilmory, Rothesay
1875 Duncan, Jas., Bannatyne Mains, Rothesay
1892 Duncan, James L., Birgedale, Knock, Rothesay—*Free Life Member*
1889 Gilmour, Thomas, Kilchattan Tile Works, Rothesay
1865†Hamilton and Brandon, The Duke of, K.T., Brodick Castle, Arran
1888 Lyon, George, Kildavaig, Ardlamont, Greenock
1889 M'Alister, Robert, Mid Ascog, Rothesay
1889 MacAlister, James, Meikle Kilmory, Rothesay
1861 Macdonald, P., The Douglas Hotel, Brodick
1889 Machie, Hugh, Ballycaul, Rothesay
1889 Machie, John, Lubas, Rothesay
1875 M'Intyre, Daniel, Dunalunt, Rothesay
1881 M'Intyre, Wm., Mount Stuart, Rothesay
1878 Mackay, Archibald M., Bruchag, Rothesay
1876 M'Pherson, Don., Queen's Hotel, Rothesay
1878 Murray, Patrick, Strabane, Brodick
1881 Stuart, J. Windsor, Rothesay
1864 Tod, William, Glenree, Lamlash
1892 Walker, James L., Bank of Scotland, Lamlash
1887 Wallace, John, Glenkill, Lamlash

## LANARK.

1875 Addie, John, Viewpark, Uddingston
1893 Aikman, C. M., M.A., B.Sc., 128 Wellington Street, Glasgow

Admitted
1882 Aikman, Thomson, Princes Court, Glasgow
1875 Alexander, Jas., 145 North Street, Glasgow
1864 Allan, Alex., Waddiefield, Hamilton
1892 Allan, Henry, Carstairs House, Carstairs
1877 Allan, James, Kirklands, Dolphinton
1878 Anderson, Robert, Arden Cottage, Calderсruix, Airdrie
1870 Andrew, W. J., Banker, Coatbridge
1872 Anstruther, Sir W. C. J. C., of Carmichael, Bart., Thankerton
1875 Bain, Sir J., 3 Park Terrace, Glasgow
1864 Bain, James, Bank of Scotland, Glasgow
1887 Bain, W. P. C., Lochrin Iron Works, Coatbridge
1878 Baird, Archibald, 67 Robertson Street, Glasgow
1886 Barr, Duncan C., Factor, Hamilton
1862 Barr, James, jun., Whiteshaw, Carluke
1882 Beckitt, C. R., Rockvilla Oil Mills, Port Dundas
1877 Beith, Gilbert, 7 Royal Bank Place, Glasgow
1882 Bertram, A. D., Kersewell, Carnwath
1852 Bertram, Wm., of Kersewell, Carnwath
1882 Bertram, Wm., yr. of Kersewell, Carnwath
1893 Boyle, Adam H., Rushhill House, Maryhill
1881 Brock, H., V.S., 112 North Street, Glasgow
1878 Brown, James, of Orchard, Carluke
1891 Brown, John Hillhead, Airdrie—*Free Life Member*
1882 Brown, John, Shields, East Kilbride
1857 Brown, John, Biggar
1877 Brownlie, R., Bogside, Newmains, Carluke
1875 Brownlie, T., 1 Carlton Terrace, Kelvinside, Glasgow
1849 Buchanan, Lieut.-Col. Carrick, C.B., of Drumpellier, Coatbridge
1876 Buchanan, Capt. J. R. G., of Scotstoune, Eastfield House, Cambuslang
1865 Burns, James C., Glenlee, Hamilton
1884 Cadzow, Robert, Borland, Biggar
1858 Campbell, William, Solicitor, Hamilton
1877 Cathcart, J. P., Lanark
1882 Chapman, Wm., Meadowhead, Airdrie
1857 Christie, T. C., of Bedley, Chryston
1880 Clark, Alexander, Todlaw, Lesmahagow
1881 Clark, W. A., Crutherland, East Kilbride
1869 Clarke, John, Hamilton
1879 Clarkson, Alexander, Corniston, Biggar
1888 Clement, And., Cheese Merchant, Glasgow
1875 Clerkson, Alexander, Cleghorn, Lanark
1890 Colebrooke, Sir Edward, of Crawford, Bart., Abington
1871 Comrie, Alex., 12 Colebrooke Street, Hillhead, Glasgow
1876 Coubrough, Wm., Sornfallow, Wiston, Biggar
1864 Cousland, James, 82 Hope Street, Glasgow
1873 Cowan, Jas., 23 St Vincent Pl., Glasgow
1888 Craig, John, High Ploughland, Strathaven
1882 Craig, John, of Bellsfield, Blantyre
1885 Craig, John, South Halls, Strathaven
1889 Craig, James, Mayfield Cottage, Hamilton
1884 Cranston, Stuart, 28 Buchanan Street, Glasgow
1882 Crawford, Alexander, Netherton, Carmunnock
1864 Cunningham, John M., George Square, Glasgow
1882 Cunningham, T. D. S., Auchlochan, Lesmahagow

Admitted
1860 Dalziel, George, Goldielea, Uddingston
1894 Davidson, Alex., Gateside, Douglas
1870 Davidson, Hugh, of Braedale, Lanark
1894 Davidson, Wm., Gateside, Douglas
1881 Dawson, John M., 56 George Square, Glasgow
1886 Denholm, Alex., Springfield, Biggar
1895 Dennistoun, A. H. O., of Golfhill, Glasgow
1892 Dippie, A. G., 144 West Regent Street, Glasgow
1889 Douglas, Rev. Sholto Douglas Campbell, of Douglas Support, Coatbridge
1876 Dunlop, C. R., of Quarter, Hamilton
1891 Dunlop, Colin, jun., Hutton Bank, Hamilton
1889 Dunn, Richard, Udston, Hamilton
1869 Dykes, J., jun., 92 St Vincent Street, Glasgow
1887 Dykes, Thomas, Bent, Lesmahagow
1887 Elliot, William, Auction Mart, Lanark
1884 Ferguson, Alex., 300 Duke St., Glasgow
1881 Findlay, John, Springcroft, Baillieston
1888 Findlay, John, Warrenhill, Thankerton
1855 Findlay, Rob., of Springhill, Baillieston
1861 Fleming, Alex., Raith, Bothwell
1882 Fleming, Andrew, Calla, Carnwath
1867 Fleming, David, Avonmill, Hamilton
1888 Fleming, David, Castleton, Rutherglen
1882 Fleming, James, Muirside, Carmunnock
1877 Fleming, John, Ploughland, Strathaven
1870 Fleming, J., Meadowbank Cot., Strathaven
1876 Fleming, J. B., of Beaconfield, Glasgow
1882 Fleming, Wm., Windlaw, Carmunnock
1863 Forrest, Peter, of Hairmyres, Shotts
1858 Fowler, John, 4 Kelvinbank Ter., Sandyford, Glasgow
1877 French, James, Mountherrick, Abington
1867 Frew, Thos., 6 Windsor Terrace, Glasgow
1872 Galbraith, W. W., Crofttoot, Gartcosh
1888 Garroway, Wm., 694 Duke St., Glasgow
1875 Gemmell, John, Glespinside, Douglas
1878 Gibb, John, Tarbrax, Carnwath
1891 Gilchrist, John, Orbiston Mains, Bellshill, Glasgow
1877 Gillies, Wm., Shawlands House, Glasgow
1888 Gilmour, Allan, yr. of Eaglesham, Glasgow
1882 Gilmour, Arthur, Crosshill, East Kilbride
1894 Glen, William, 32 Berkeley Terrace, Glasgow
1877 Goff, Dr Bruce, The Lindens, Bothwell
1887 Goodwin, John, Clydeview, Motherwell
1893 Gordon, Henry Erskine, Aikenhead House, Cathcart
1882 Graham, Thomas, 40 St Enoch Square, Glasgow
1873 Grahame, Jas., Western Club, Glasgow
1887 Grant, Henry O. Ogilvie, 53 Miller St., Glasgow
1876 Gray, John, 181 Renfrew Street, Glasgow
1867 Greenshields, J., West Town, Lesmahagow
1881 Haddow, Robt., Cold Chapel, Abington
1894 Hamilton, Claude G. M'Neil, Broomhill, Larkhall
1875 Hamilton, Gavin, of Auldtown, Lesmahagow
1880 Hamilton, Gavin, jun., B. L. Co. Bank, Lesmahagow
1869 Hamilton, Jas., Woolfords, Cobbinshaw
1857 Hamilton of Dalzell, Lord, Dalzell, Motherwell
1893 Hamilton, Robert, High Motherwell, Motherwell
1877 Hamilton, Thomas, Poniel, Douglas
1889 Hardie, David, Sub-Factor, Dalzell, Motherwell
1852 Harvie, Rev. W., of Brownlee, Carluke

Admitted
1895 Hamilton, C. G. Henderson, of Dalserf, Netherburn
1862 Hendrie, John, 74 Bath Street, Glasgow
1868 Houldsworth, Jas., of Coltness, Wishaw
1872 Houldsworth, W. J., Coltness House, Wishaw
1862 Hozier, Sir W. W., of Newlands and Mauldslie Castle, Bart., Carluke
1860 Hunter, William, Craighead, Abington
1878 Inch, John, Howburn, Walston, Biggar
1870 Inch, Thomas, Gilkerscleuch, Abington
1855 Jack, Robt., Banker, Motherwell
1857 Jeffray, John, Cardowan House, Millerston
1893 Johnston, George, Mossefield, Springburn, Glasgow
1876 Johnston, James, Pather Farm, Wishaw
1878 Johnston, Jas., Lochburnie, Maryhill
1888 Kennedy, Hugh, Contractor, Partick
1893 Kennedy, M. H., Contractor, Partick, Glasgow
1888 Kerr, James, New Mains, Douglas
1857 Kerr, Robert, West George St., Glasgow
1875 Kidston, Richard, 81 Great Clyde Street, Glasgow
1869 King, Robert, Levernholm, Hurlet
1891 Laidlaw, John, 98 Dundas Street, S.S., Glasgow
1882 Lamberton, Andrew, Sunnyside Works, Coatbridge
1884 Lamington, Lord, Lamington House
1864 Latta, M. R., Carmyle, Tollcross, Glasgow
1893 Leiper, Robert, Yardbent, Strathaven
1872 Lockhart, Sir S. M., of Lee and Carnwath, Bart., Lanark
1884 Lockhart, Major-General Graeme, of Castlehill, C.B., Cambusnethan House, Wishaw
1870 Lockhart, Wm. Elliott of Cleghorn, Lanark
1857 Logan, Andrew, 1 Hampden Terrace, Mount Florida, Glasgow
1874 Love, Jas., 12 St James Street, Paisley Road, Glasgow
1885 M'Alpine, A. N., Glasgow and West of Scotland Technical College, 60 John Street, Glasgow—*Botanist to the Society*
1868 M'Call, Prof. J., Veterinary College, Glasgow
1846 M'Call, Henry, of Daldowie, Glasgow
1860 Macfarlane, Donald, Balmuildy, Bishopbriggs
1884 M'Farlane, John, 151 North St., Glasgow
1875 MacGregor, G. Sheriff, 5 Huntly Gardens, Glasgow
1872 M'Ilwraith, Jas., 92 Regent St., Glasgow
1864 Mackie, J. L., Ravelston, Great Western Road, Glasgow
1894 M'Kirdy, W. A. Scott, of Birkwood, Lesmahagow
1876 Maclae, A. Crum, of Cathkin, 140 St Vincent Street, Glasgow
1871 M'Laren, James, 182 Hope Street, Glasgow
1888 MacLellan, Robert, Conservative Club, Glasgow
1888 M'Lennan, Bailie James, 40 St Andrew Street, Glasgow
1882 M'Neilage, A., 93 Hope Street, Glasgow
1875 M'Pherson, D., 95 Finlay Drive, Dennistoun, Glasgow
1856 Macpherson, J., Blantyre Farm, Glasgow
1882 M'Queen, David, Factor, Wishaw
1884 M'Queen, Hope, Midlock, Abington
1884 M'William, Andrew, 38 Queen Street, Glasgow
1874 Main, Jas. A. R. (A. & J. Main & Co.), Gordon Street, Glasgow
1879 Main, R. R. (A. & J. Main & Co.), Possil Park, Glasgow

Admitted
1880 Marshall, James, Airbles, Motherwell
1880 Marshall, John, Sandyford, Holytown
1858 Martin, John, 50 West Scotland Street, Glasgow
1870 Merricks, William, 166 Buchanan St., Glasgow
1884 Millar, John, 16 St Vincent Place, Glasgow
1892 Millar, John, Fern Hill, Cathkin, Rutherglen
1868 Miller, G. J., of Frankfield, Shettleston
1885 Mitchell, James, Auchengray House, Airdrie
1893 Mitchell, James, Hazleside, Douglas
1894 Mitchell, John, 18 Shaftesbury Street, Glasgow
1888 Mitchell, Robt., M.R.C.V.S., 18 Shaftesbury Street, Glasgow
1894 Mitchell, Robert, jun., 18 Shaftesbury Street, Glasgow
1889 Mitchell, William, Hazleside, Douglas
1861 Moffat, George, Alma Place, Shawlands, Glasgow
1893 Moore, Wardrop, yr. of Greenhall, Blantyre
1875 Morton, J., Nether Abington, Abington
1859 Mosman, H., of Auchtyfardle, Lesmahagow
1874 Muirhead, William, Winton Place, Uddingston
1875 Murdoch, Alex., Gartcraig, Shettleston
1888 Murdoch, James, jun., Gartcraig, Shettleston
1893 Murdoch, James C., West Hallside, Newton, Glasgow
1874 Murdoch, J. F., East Hallside, Newton
1875 Murdoch, John, Carntyne, Shettleston
1857 Murdoch, Robert, Hallside, Cambuslang
1893 Murdoch, William, 8 Eglinton Lane, Glasgow
1894 Murray, James, Low Ploughland, Strathaven
1862 Murray, John L., of Heavyside, Biggar
1884 Murray, John, Parkhall, Douglas
1874 Murray, Robert G., of Spittal, Biggar
1879 Murray, W. G. G., 93 Hope Street, Glasgow
1875 Napier, John S., of Lethame, Strathaven
1893 Neilson, James, of Mossend, Carfin Hall, Holytown
1867 Neilson, William, Bank of Scotland, Bellshill
1887 Nimmo, Thomas, Lawhead, Forth
1881 Park, James, Dechmont, Cambuslang
1877 Paterson, G. R., Drumalbin, Thankerton
1884 Paterson, James, jun., Over Abington, Abington
1862 Paterson, John, Nether Howcleugh, Moffat
1887 Paterson, John, of Torfoot, Strathaven
1848 Paterson, Robert, of Birthwood, Biggar
1884 Paterson, Wm., Grange, Thankerton
1885 Paton, James, Glencaple, Abington
1878 Payne, James, 40 Union Street, Glasgow
1854 Pearson, Andrew A., of Springfield, Carluke
1869 Pender, J., Springhill, Stane, Shotts
1873 Pitblado, C. B., 72 Albert Road, Crosshill, Glasgow
1889 Pollock, James, V.S., Hamilton
1884 Pollock, W., Yoker Mains, Glasgow
1884 Pringle, John, Castle Mains, Douglas
1892 Ralston, Chas. W., Garscube, Maryhill
1890 Ramsay, Professor G. G., University, Glasgow
1882 Rattray, Patrick, C.A., 88 St Vincent St., Glasgow
1893 Reid, C., Photographer, Wishaw
1867 Reid, F. R., of Gallowflat, Rutherglen
1879 Reid, F. R., jun., Gallowflat, Rutherglen

Admitted
1885 Reid, William, 140 St Vincent Street, Glasgow
1882 Renwick, Robert, Buchley, Bishopbriggs
1874 Richardson, George, Western Club, Glasgow
1867 Ritchie, John, Whitecastle, Biggar
1882 Robb, Geo., 11 Germiston Street, Glasgow
1882 Rodger, Hugh, Estates Office, Airdrie
1884 Ross, John M., 2 Devonshire Gardens, Glasgow
1894 Russell, Alexander, 175 West George Street, Glasgow
1867 Russell, Archd., Auchenraith, Bothwell
1877 Russell, George, Carnwath
1875 Russell, James, National Bank, Airdrie
1882 Russell, James, Allanton, Hamilton
1871 Salmond, David S., 40 St Enoch Square, Glasgow
1875 Sanderson, James, West Yard Houses, Carnwath
1884 Sandilands, R., South Cumberhead, Lesmahagow
1868 Scott, James, Bogton, Bishopbriggs
1878 Scott, Jas., Distiller, Garrion Tower, Wishaw
1868 Scott, J., Springfield House, Uddingston
1868 Scott, M., Bogton, Bishopbriggs
1875 Scott, William, Priestfield, Blantyre
1882 Shirlaw, James, Carfin, Motherwell
1889 Shirlaw, John, Howgate, Carluke
1877 Skead, George, Royal Bank, Wishaw
1894 Sleigh, C. W., Estate Office, Blackwood, Lesmahagow
1889 Smellie, James, Coursington, Motherwell
1856 Smith, Andrew, Milnwood, Lanark
1862 Smith, George, 5 Langside Terrace, Shawlands, Glasgow
1857 Smith, H., 9 Kelvinside Terrace (North), Glasgow
1867 Somerville, G. P., Muirhouse, Carnwath
1886 Speir, John, Newton Farm, Newton, Glasgow
1875 Spencer, A., 160 Hope Street, Glasgow
1888 Sprot, Major A., of Garnkirk, Chryston, Glasgow
1883 Stalker, Donald, Mossend Farm, Mossend, Glasgow
1861 Stark, W., Point House, Cattle Wharf, Glasgow
1891 Steel, Matthew Taylor, 185 Buchanan Street, Glasgow
1891 Stein, A. H., of Kirkfield, Lanark
1889 Steven, Hugh, Milton Iron Works, Glasgow
1872 Stevenson, Wm., Lochgrog, Bishopbriggs
1869 Stewart, D. W., Cartland, Lanark
1854 Stewart, John, Cattle Market, Glasgow
1879 Stewart, John, Mossvale House, Chryston, Glasgow
1881 Stewart, R. K., of Murdostoun, Newmains
1855 Stodart, David, Banker, Lanark
1889 Stuart, Col. Harington, of Torrance, East Kilbride
1892 Swan, James G., 74 Bath Street, Glasgow
1881 Tennant, James, 7 Hillend Gardens, Hyndland Road, Glasgow
1881 Tervit, John, Boat, Thankerton
1889 Thomson, A. J., of Huntfield, Biggar
1869 Thomson, John, 41 Mitchell Street, Glasgow
1882 Thomson, Seton (Rose, Murison, & Thomson), St Vincent Place, Glasgow
1892 Thomson, Seton M., Golfhill, Glasgow
1884 Thomson, Wm., Smith Street, Kinning Park, Glasgow
1875 Thomson, W. G., 41 Mitchell Street, Glasgow

Admitted
1877 Thorburn, Robert, Stonehill, Thankerton
1882 Ure, John, 66 Washington Street, Glasgow
1856 Vere, C. E. Hope, Blackwood, Lesmahagow
1882 Vere, J. C. Hope, of Blackwood, Lesmahagow
1882 Walker, William, 84 Braeside Street, Glasgow, W.
1882 Wallace, Hugh, 30 Havelock Street, Glasgow
1893 Wallace, Jas., Graham Square, Glasgow
1888 Wallace, John, 273 Argyle Street, Glasgow
1882 Wallace, John, The Ingle, Rutherglen
1893 Wallace, Robert, Graham Square, Glasgow
1879 Wallace, W. (John Wallace & Sons), Graham Square, Glasgow
1882 Watson, Adam, Oggs Castle, Newbigging, Lanark
1888 Watson, G. M., Baitlaws, Lamington
1883 Watson, John, 205 West George Street, Glasgow
1857 Watson, John, of Earnock, Hamilton
1884 Watson, Robert, Culteraliers, Biggar
1880 Watt, John, Drumgray, Airdrie
1875 Watt, Robert, Solicitor, Airdrie
1877 Weir, James, Sandilands, Lanark
1894 White, David, 182 Hope Street, Glasgow
1878 Williams, Robert, The Green, Wishaw
1884 Williamson, Alex., Chesterhall, Wiston, Biggar
1883 Wilson, Andrew, Dalzell, Motherwell
1888 Wilson, James, Westburn, Cambuslang
1895 Wilson, Peter, 26 Kelvin Drive, Glasgow
1877 Wingate, Andrew, Castlehill, Wishaw
1889 Wood, Alex., 8 & 10 Stockwell Street, Glasgow
1877 Wragg, Charles, 4 Stockwell Street, Glasgow
1873 Young, Wm., Waterbank, Carmunnock

## RENFREW.

1887 Alexander, P. D., Dunmyat, Bridge of Weir
1884 Allan, David, M.R.C.V.S., Clarkston, Busby
1886 Blair, James, Bankfoot, Inverkip
1843†Blantyre, Lord, Erskine, Glasgow
1857 Blythswood, Lord, Blythswood, Renfrew
1892 Bowie, William, Blackbyres, Barrhead
1884 Bryce, David, Abbots Inch, Paisley
1805 Burns, Sir John, of Castle Wemyss, Bart., Wemyss Bay
1893 Campbell, J. M., Writer, Auldfield Place, Pollokshaws
1884 Clark, James, Burnside, Mearns
1884 Clark, Wm., Netherlea Farm, Cathcart
1893 Coats, Andrew, Ferguslie, Paisley
1888 Coats, Sir Thos. Glen, Bart., of Ferguslie Park, Paisley
1850 Colquhoun, J., Corkerhill, Pollokshaws
1884 Crawford, John W., Greenock
1878 Cross, Alex., jun., Eastbank, Langbank
1881 Cross, David, Eastbank House, Langbank
1880 Cuninghame, J. C., of Craigends, Johnstone
1894 Dawson, Robert, Donchilly Farm, Pollokshaws
1882 Ferguson, A. R., Writer, Neilston
1875 Ferguson, Peter, Rock Cottage, Renfrew
1883 Fleming, Wm., Fulwood Mains, Linwood
1868 Gairdner, Charles Brown, Newton-Mearns
1857 Gilmour, Matt., Town of Inchinnan, Paisley
1857 Glegg, J., Factor, Milliken House, Johnstone
1893 Gordon, H. E., Aikenhead House, Cathcart
1875 Houstoun, Geo. L., of Johnstone, Johnstone
1894 Houston, William F., V.S., Paisley
1879 Howie, William, Finnochbog, Inverkip
1894 Hunter, Andrew, Braehead House, Cathcart
1857 Hunter, James, Braehead House, Cathcart
1884 Jackson, Jas., Carolside, Busby
1875 Jamieson, Wm., Tighnamara, Wemyss Bay
1882 Locke, Matthew, Arthurlie, Barrhead
1875 Love, Alex., Margaret's Mill, Kilmalcolm
1875 Macdowall, H., of Garthland, Lochwinnoch
1884 M'Kie, H. B., Freeland, Erskine
1885 Mactavish, D. A., Solicitor, Johnstone
1873 Mather, Wm., Kirkhill, Newton Mearns
1894 Mather, William, Netherplace, Mearns
1889 Maxwell, Sir John Maxwell Stirling, of Pollok, Bart., Pollokshaws
1864 Myles, James, Deanside, Renfrew
1881 Park, Walter, Hatton, Bishopton, Renfrew
1853 Paterson, Jas., 32 Eldon Street, Greenock
1867 Peile, H. R. B., Mansion House, Greenock
1873 Pollok, John, Paper Mill, Langside
1883 Pottie, Alexander, V.S., Paisley
1875 Ramsay, John, Butcher, Kilbarchan
1888 Reid, Colin, Castle Farm, Mearns
1882 Reid, Robert, Writer, Lochwinnoch
1888 Reid, William, Titwood Farm, Mearns
1863 Richardson, David, of Hartfield, Greenock
1893 Richmond, Andrew, M.B., C.M., 57 Love Street, Paisley
1868 Riddell, David, Blackhall, Paisley
1880 Scott, A., 24 Mearns Street, Greenock
1882 Scott, James B., Ryeraes, Linwood
1894 Scott, William, Denniston, Kilmalcolm
1891 Speirs, Alex. Archibald, of Elderslie, Houston House, Johnstone
1848†Stewart, Sir M. R. Shaw, of Greenock and Blackhall, Bart., Ardgowan, Inverkip
1875 Stodart, G., Netherton, Newton Mearns
1880 Taylor, William, Park Mains, Renfrew
1894 Thomson, Malcolm B., Park House, Renfrew
1892 Tough, Alex., Clyde Rope Work, Greenock
1888 Wallace, John, Broadlee, Neilston
1883 Wilson, John, Erskine, Bishopton
1863 Wilson, Robert, Manswrae, Bridge of Weir
1888 Young, Alex., Castlehill Farm, Eaglesham
1883 Young, R. C., Netherfield, Paisley

# 2.—PERTH DISTRICT.

EMBRACING THE

## COUNTIES OF FIFE, FORFAR (WESTERN DIVISION), KINROSS, AND PERTH (EASTERN DIVISION).

### FIFE.

Admitted
1883 Aitken, George Lewis, Boglilly, Kirkcaldy
1888 Allan, James, Dysart
1875 Anderson, Charles, Fettykil, Leslie
1877 Anderson, David, Cassendilly, Cupar-Fife
1883 Anderson, David A., Woodside House, Ladybank
1867 Anderson, W. H., Anchor Lodge, Anstruther
1892 Anstruther, Sir R., of Balcaskie, Bart., Pittenweem
1862 Arnot, David, Friarton, Newport, Fife
1886 Arnot, Thomas, Newton of Falkland, Falkland
1894 Auchmuty, George, Bowhouse of Wemyss, West Wemyss
1884 Auchterlonie, James, Dothan, Kirkcaldy
1844 Aytoun, R. S., of Inchdairnie, Kirkcaldy
1873 Baird, William, of Elie, Fife
1884 Balfour, Edward, yr. of Balbirnie, Markinch
1857 Balfour, Major F. W., of Fernie Castle, Collessie
1890 Balfour, Francis, yr. of Fernie, Fernie Castle, Collessie
1839 Balfour, John, of Balbirnie, Markinch
1893 Balfour, Thomas C., Carberry, Leven
1893 Balfour, William, jun., Ovenstone, Pittenweem
1871 Ballingal, Neil, Sweetbank, Markinch
1861 Ballingall, John, Dunbog, Newburgh
1890 Banks, James, Pitteddie, Kirkcaldy
1886 Baxter, Edward Gorrel, of Teasses, Largo
1891 Baxter, John Henry, of Gilston, Largo
1893 Bayne, James, Muirhead, Freuchie
1856 Bell, David, Todhall, Cupar-Fife
1893 Bell, George, Downfield, Ladybank
1879 Bell, Dr James M., Kettle
1880 Bell, John, Stenton, St Monance
1890 Bell, Thomas, Todhall, Cupar-Fife
1865 Bell, T., Craigkennochy Terrace, Burntisland
1877 Bennet, Arthur, South Pitkinnie, Lochgelly
1893 Berwick, Andrew, Hayston, Leuchars
1861 Berwick, David, Ardross, Elie
1848 Bethune, Alexander, Elie
1833 Bethune, Colonel R., of Nydie, St Andrews
1862 Beveridge, George, Kirkcaldy
1869 Beveridge, Jas., Crombie, Dunfermline
1872 Beveridge, William, of Bonnyton, Dunfermline
1881 Beveridge, William, jun., Eastgrange, Dunfermline
1879 Bisset, Alex., Balfarg, Markinch
1883 Black, James, Tullybreck, Markinch

Admitted
1890 Black, John, Nether Pratis, Leven
1889 Blyth, James, jun., Logie, Cupar-Fife
1890 Blyth, William, Easter Kincaple, St Andrews
1870 Bonthrone, A., Newton of Falkland, Falkland
1893 Borrowman, James, V.S., Cupar-Fife
1887 Bowman, George M., of Logie, Cupar-Fife
1859 Bowman, James, Newark, St Monance
1890 Braid, John, Abercrombie, St Monance
1893 Brewster, John, Newhall, Crail
1891 Brown, Andrew, Rossie, Collessie
1894 Brown, Hugh, Colton Mains, Dunfermline
1876 Brown, John, of Colton, Dunfermline
1842 Bruce, John, W.S., 8 Pilmuir Links, St Andrews
1889 Buttercase, Andrew, Uthrogle, Cupar-Fife
1894 Butters, Hugh, Masterton, Dunfermline
1894 Carmichael, M. T., Knockhill, Newport, Fife
1880 Carnegie, James, of Aytoun Hill, Newburgh
1869 Carswell, David, Blacketyside, Leven
1885 Carswell, J. H., Straiton, Leuchars
1868 Cartwright, T. R. B. Leslie Melville, Melville House, Ladybank
1886 Cathcart, James T., yr. of Pitcairlie Newburgh
1857 Cathcart, R., of Pitcairlie, Newburgh
1883 Cheape, Captain G. C., of Wellfield, Strathmiglo
1889 Cheape, Mrs, of Wellfield, Strathmiglo
1881 Cheape, J., of Lathockar, St Andrews
1879 Christie, F. W., Dairsie Mains, Cupar-Fife
1890 Christie, James M., Scotscraig, Tayport
1874 Christie, John, Kirktonbarns, Tayport
1880 Clark, Alex., Balmullo, Leuchars
1871 Clark, Wm., 57 Cross Gate, Cupar-Fife
1870 Cleghorn, Dr, of Stravithy, St Andrews
1894 Clement, James, Balkaithly, Dunino, R.S.O.
1894 Clement, John, Clatto, St Andrews
1890 Constable, John, M.D., Leuchars
1893 Cook, David, Luthrie, Cupar-Fife
1892 Corstorphine, J. E. E., Inchyre Abbey, Newburgh, Fife
1878 Craig, John, Craigencalf, Kinghorn
1866 Crawford, R., Crooks House, Inverkeithing
1894 Crichton, Jas., Boyne House, Ladybank
1879 Cunningham, David, Dalachy, Aberdour, Fife
1879 Cunningham, John, Burntisland

Admitted
1883 Cunningham, T. D., The Mount, Cupar
1880 Curr, James, Knockhill, Newport, Fife
1894 Currie, Walter T., of Trynlaw, Rankeillor, Cupar-Fife
1881 Curror, Peter, Maltster, Kirkcaldy
1880 Davidson, George P., Kirkbank, Burntisland
1894 Dickie, Alfred, Devon, Kingskettle
1851 Dingwall, William, Ramornie, Ladybank
1891 Dott, Robt., Muir Farm, Pathhead, Kirkcaldy
1873 Drummond, J., jun., Blacklaw, Dunfermline
1860 Dryburgh, J., Kininmonth, Cupar-Fife
1861 Drysdale, Wm., of Kilrie, Kinghorn
1884 Dun, George, Easter Kincaple, St Andrews
1888 Duncan, Miss C. H. A. Morison, of Naughton, Dundee
1894 Duncan, David J. Russell, Kilmux, Leven
1883 Duncan, John, Kirkmay, Crail
1871 Duncan, John E., Balrymouth, St Andrews
1855 Duncan, Robert, of Kirkmay, Crail
1893 Duncan, Robert, Craigfoodie, Cupar-Fife
1885 Duncan, Thomas L., Pusk, Leuchars
1881 Elder, Hugh, Dunfermline
1875†Elgin and Kincardine, the Earl of, Broomhall, Dunfermline
1867 Elphinstone, Hon. Edward B. C. B., Comrie Castle, Dunfermline
1860 Erskine, Sir Thomas, of Cambo, Bart., Kingsbarns
1893 Erskine, Colonel W., yr. of Cambo, Kingsbarns
1892 Fair, Alex., Shawsmill, Cardenden
1891 Fairlie, J. O. R., of Myres Castle, Auchtermuchty
1890 Farmer, A. Douglas, Kinkell, St Andrews
1881 Farmer, A. F., of Brownhills, St Andrews
1884 Farmer, Robert, of Kingask, St Andrews
1882 Ferguson, R. C. Munro, of Raith, M.P., Kirkcaldy
1881 Fergusson, David, of Foxton, Cupar-Fife
1891 Ferrie, David, Parbroath, Cupar-Fife
1892 Finlay, Archibald, Markinch
1850 Finlay, John, Lochend, Lochgelly
1893 Finlayson, James, Beley, Stravithie
1893 Fleming, Andrew, Hallcases, Ceres
1861 Flockhart, J., Banker, Colinsburgh
1873 Forgan, James, Sunnybraes, Largo
1891 Fraser, Robt., Middle Balbeggie, Kirkcaldy
1861 Fyfe, Robert, Wester Nether Urquhart, Gateside, Fife
1879 Fyshe, Jas., jun., Treaton, Markinch
1888 Galloway, John, Milton, Leuchars
1871 Gibb, David, Balmonth, Pittenweem
1893 Gibb, James, Easthall, Cupar-Fife
1877 Gibson, James, Aithernie, Leven
1877 Gilchrist, Andrew, Carvenom, Anstruther
1871 Gillespie, Alex., Balmeadowside, Cupar-Fife
1841 Gillespie, D., of Mountquhannie, Cupar-Fife
1872†Gilmour, John, of Montrave, Leven
1887 Goodall, Thos., Cardenburns, Cardenden
1894 Gordon, T. P., Prize Poultry Farm, Thornton
1888 Gourlay, J. Murray, 1 Hope St., St Andrews
1887 Grace, Stuart, St Andrews
1885 Gray, T. M., Barony Cottage, Cupar-Fife
1892 Greig, Robert Blyth, Balcurvie, Windygates—*Free Life Member*
1860 Haig, H. V., of Ramornie, Ladybank

Admitted
1881 Hamilton, Jas. A., West Muircambus, Kilconquhar
1871 Heggie, R. B., West End House, Kirkcaldy
1891 Henderson, A. L., Kingsdale, Kennoway
1881 Hepburn, James, Forth Bank, Kinghorn
1877 Hepburn, John, Kinghorn
1876 Herdman, B. A., Falkland Wood, Falkland
1872 Hill, David, Upper Magus, St Andrews
1881 Hill, John, Langside, Kennoway
1893 Horn, David, Drumcarro, St Andrews
1884 Husband, D., Struthers, Cupar-Fife
1891 Husband, Robt., Solicitor, Dunfermline
1893 Husband, Thos. R., Gellet, Dunfermline
1883 Hutchison, Alex., Ingleside, Kirkcaldy
1891 Hutton, John, Well Park, West Anstruther
1891 Inglis, James, Redhouse, Cardenden, R.S.O.
1887 Inglis, John, of Colluthie, Cupar-Fife
1887 Inglis, R. T., Blinkbonny Lodge, Newburgh
1869 Irvine, Walter, of Grangemuir, Pittenweem
1876 Jamieson, W. T., Solicitor, Anstruther
1890 Johnston, John, New Inn, St Andrews
1877 Johnston, L., Sands, Kincardine-on-Forth
1882 Johnston, S. W., Fincraigs, Newport
1874 Johnstone, W. M., Banker, Cupar-Fife
1890 Kay, Alex., Flass, Newport
1863 Kay, William, Inch Farm, Kincardine-on-Forth
1893 Kelloch, George, Balmerino, Newport
1865 Kidd, A. F., High St., West Aberdour
1859 Kininmonth, Peter, Collairnie, Newburgh, Fife
1884 Kinnear, John Boyd, of Kinloch, Collessie
1871 Kinross, Thomas, Wester Balbeggie, Kirkcaldy
1879 Knight, Robert, jun., V.S., Dunfermline
1893 Kydd, John, Rhynd, Leuchars
1893 Lauder, Thos., St Nicholas, St Andrews
1891 Lawson, Alex., of Burnturk, Annfield, Kettle
1890 Lawson, Henry Graham, Forthfield, Anstruther
1867 Lawson, Thos., of Carriston, Markinch
1863 Lee, John, East Coates, Largo
1881 Lees, David, Pitscottie, Cupar
1862 Leslie, Hon. G. Waldegrave, Leslie House, Leslie
1889 Lochead, Matthew, Wester Balgarvie, Cupar-Fife
1854 Macdonald, Alex., of Edenwood, Cupar-Fife
1869 M'Farlane, James, Writer, Dunfermline
1890 M'Gibbon, John, Bankhead, Leven
1890 M'Gregor, Donald, Broomhall Estate Office, Charlestown
1890 M'Gregor, James Fleming, 71 Market Street, St Andrews
1878 M'Intosh, Dr, University, St Andrews
1871 Maitland, Henry, of Balmungo, St Andrews
1879 Marshall, Walter, of Lochmaloney, Cupar
1879 Martin, James, of Priestfield, Pitlessie, Ladybank
1893 Meiklem, James Begg, Kirkcaldy
1893 Meiklem, William Begg, Kirkcaldy
1880 Meldrum, D. B., of Kincaple, St Andrews
1859 Meldrum, J., of Eden Bank, Pitlormie, Cupar-Fife
1893 Melville, Thomas Robertson, Kettle
1875 Menzies, Fergus, Blackhall, Dunfermline

Admitted
1877 Millar, J., of Waulkmill, Dunfermline
1890 Miller, James Gilbert, Starr, Cupar-Fife
1870 Millie, George, St Mary's, Cupar-Fife
1893 Milne, John, Annfield, Cardenden
1883 Mitchell, Alex., Redwells, Kinglassie
1894 Mitchell, Alexander, of Luscar, Dunfermline
1861 Mitchell, John, Fliskmiln, Newburgh
1872 Mitchell, John, Newbigging, Burntisland
1859 Mitchell, Robert, 3 Bonnygate, Cupar-Fife
1893 Morgan, John, Nocknary, Auchtermuchty
1878 Morrison, B. G. W., of Falfield, Cupar-Fife
1890 Morton, David, Craighead, Crail
1894 Morton, John, Givan, Wormiston, Crail
1894 Moubray, Capt. H. H. Carew, of Otterston, Aberdour
1879 Muckersie, Henry, Drumfin, Dunfermline
1890 Mudie, T. E., Greenside, Largo
1893 Muir, Alex., of Ballinkirk, Markinch
1875 Muirhead, T., Townhill Store, Dunfermline
1883 Nairn, M. B., of Rankeillour, Cupar
1884 Nisbet, T. M., Forthar, Kettle
1880 Normand, William J., Dysart
1873 Oliphant, T. T., Queen Mary's, St Andrews
1892 Orchison, Alex., of Torr, Cupar-Fife
1882 Osborne, David, Banker, Cupar-Fife
1886 Page, Walter, Bogleys, Kirkcaldy
1859 Paton, John, Kirkness, Lochgelly
1893 Porter, James, Prinlaws House, Leslie
1864 Prentice, G., of Strathore, Thornton
1889 Purvis, Major A. B., R.A., Kinaldy, Stravithy, R.S.O.
1844 Purvis, John, of Kinaldy, Stravithy, R.S.O.
1895 Ramsay, John Inch, Pittenweem
1864 Reekie, A., Walton, Auchtertool, Kirkcaldy
1886 Reid, Andrew, V.S., Auchtermuchty
1882 Reid, John, of Dunduff, Dunfermline
1893 Reid, Robert, The Grove, Strathmiglo
1878 Rigg, James Home, of Tarvit, Cupar-Fife
1861 Rintoul, D., Mains of Blebo, Cupar-Fife
1893 Rintoul, Wm., Mains of Blebo, Cupar
1873 Roberts, J., Greenhead of Arnot, Leslie
1860 Robertson, Dr Charles, 16 Craigholm, Burntisland
1882 Robertson, Donald, of Mayfield, Cupar-Fife
1859 Robertson, J., Denbrae, Cupar-Fife
1893 Roger, William, Kingsbarns
1891 Ross, Nicol, Cattle-salesman, Dunfermline
1892 Rosslyn, The Earl of, Dysart House, Kirkcaldy
1859 Russell, David, Silverburn, Leven
1882 Russell, George, Hatton, Largo
1869 Russell, James, of Kinsleith, Cupar-Fife
1893 Scott, Douglas, Newton of Wemyss, Fifeshire
1883 Scott, James Addison, 3 Kinburn Terrace, St Andrews
1893 Scott, John, Newton of Wemyss, Fifeshire
1894 Shepherd, William, Solicitor, Leven
1883 Sheppard, Thomas, Moonzie, Cupar
1879 Sime, Alex., Dumbarnie, Largo
1857 Small, L., of Foodie, Cupar
1886 Smith, Andrew, Hilltarvit, Cupar-Fife
1882 Smith, James T., Duloch, Inverkeithing
1886 Smith, Thomas, Inverdovat, Newport
1878 Smith, Wm., Balbougie, Inverkeithing
1870 Stark, Robert, Kirkcaldy
1876 Stenhouse, J. S., of Northfod, Dunfermline
1882 Stevenson, John, Lillyhill House, Dunfermline
1877 Stewart, Duncan, The Grange of Lindores, Newburgh
1892 Stewart, Hugh, Lumphinnans, Cowdenbeath
1894 Stewart, Wm., Ingrie, Leslie
1893 Stirling, John, Auchmuthy, Markinch
1890 Storrar, David, Land Surveyor, Cupar-Fife
1891 Storrar, Richard, Pyestone, Markinch
1889 Syme, John, Nether Strathkinness, St Andrews
1857 Syme, William, Craigie, Leuchars
1893 Taylor, William, Bankhead, Thornton
1871 Thom, James, of Leden Urquhart, Gateside, Fife
1875 Thom, James F., Wellsgreen, Windygates
1891 Thom, James H., Coates, Largo
1879 Thom, R. D., Pitlochie, Strathmiglo
1891 Thomson, Henry, Perceval, Buckhaven
1848†Thomson, Colonel John A., of Charleton, Colinsburgh
1877 Tod, James, Easter Cash, Strathmiglo
1875 Troup, Alexander, Strathmiglo
1873 Tulloch, James, Dales, Inverkeithing
1893 Turnbull, Mark, Randerston, Crail
1878 Walker, Arch., Banker, Auchtermuchty
1890 Walker, Peter C., Kilmaron, Cupar-Fife
1875 Walker, Thos., Demperston, Auchtermuchty
1882 Wallace, George, Lebanon House, Cupar-Fife
1861 Wallace, James, Brake, St Andrews
1891 Wallace, John, Duniface, Leven
1880 Wallace, T. A., Banker, Burntisland
1875 Wallace, Wm., Kincaple, Guardbridge
1891 Walls, Donald M., Grain Merchant, Dunfermline
1883 Walls, Robert, Grange, Burntisland
1892 Wardlaw, John, Tough Mill, Dunfermline
1893 Watson, Arthur, Kinnear, Leuchars
1873 Watt, Alex., 4 Home Park, Aberdour
1893 Watt, Frank M. Caldwell, Collessie
1871 Watt, George, Kilmany, Cupar-Fife
1882 Watt, W., Seed Merchant, Cupar-Fife
1890 Webster, Thomas, Nisbetfield, Ladybank
1874 Wedderburn, H. S., of Wedderburn, Birkhill, Cupar
1884 Weighton, J. G., of Priorletham, St Andrews
1889 Wemyss, Alex. Watson, Denbrae, St Andrews
1872 Wemyss, R. G. E., of Wemyss, Kirkcaldy
1875 Whyte, John, Lundin Mill, Largo
1894 Wilkinson, John, Knockhill, Newport
1892 Wilson, Daniel, Reedieleas, Auchtermuchty
1882 Wilson, Geo., Gladstone Cottage, Cupar
1892 Wilson, John Hardie, D.Sc., F.R.S.E., St Andrews—*Free Life Member*
1880 Wilson, P., Seed-crusher, Burntisland
1882 Wilson, Robt. M., Fodbank, Dunfermline
1877 Wood, Major William, Falkland
1859 Young, A., Lochtyside, Thornton, Kirkcaldy
1875 Younger, J. B. B. C., Balgrummo, Leven

## FORFAR

(Western Division).

1882†Airlie, The Earl of, Cortachy Castle
1881 Alexander, John, Ballindarg, Kirriemuir
1890 Andrew, James M., Magdalenes, Kirkton, Dundee
1853 Arklay, John, Seafield, Broughty Ferry
1871 Arnot, Wm., Glamis Mains, Glamis

Admitted
1884 Auchterlonie, Alex., Viewbank, Coupar-Angus
1886 Ballingal, Hugh, Ardarroch, Dundee
1889 Batchelor, Francis M., Craigo, Dundee
1890 Baxter, George Washington, Ashcliff, Dundee
1893 Bell, Pat. Arnot, Auchtertyre, Newtyle
1890 Bell, Thomas, of Belmont, Dundee
1894 Bell, William, Balnuith, Dundee
1890 Bell, William Forsyth, Barns of Claverhouse, Dundee
1890 Berry, James, Merchant, Dundee
1876 Black, John, Cortachy, Kirriemuir
1879 Bruce, Andrew, Jordanston, Meigle
1867 Burr, Rev. P. Lorimer, Lundie Manse, Dundee
1861 Buttar, David, Corston, Coupar-Angus
1882 Buttar, Thomas A., Corston, Coupar-Angus—*Free Life Member*
1881 Cameron, James, Murthill Farina Works, Forfar
1871 CAMPERDOWN, The Earl of, Camperdown, Dundee
1890 Carmichael, James, Mayfield, Dundee
1858 Carnegie, W., yr. of Dunlappie, Coul, Forfar
1891 Carver, John, Kinloch, Meigle
1884 Clark, James, F.R.C.V.S., Abbeyhill, Coupar-Angus
1893 Cowans, David S., of West Mains, Auchterhouse, Dundee
1881 Cowpar, James, Over Migvie, Kirriemuir
1890 Cox, Alfred W., Beechwood, Lochee
1890 Cox, Edward, of Cardean, Meigle
1882 Cox, Geo. M., Dryburgh House, Dundee
1894 Crichton, And., Estate Office, Glamis
1883 Darling, J. F. Stormonth, of Lednathie, Kirriemuir (38 Palmerston Place, Edinburgh)
1890 Dewar, James C., Airlie Arms Hotel, Kirriemuir
1881 Duke, Wm., Newbarns, Kirriemuir '
1883 Duncan, John, Braehead, Kirriemuir
1879 Duncan, Patrick G., East Memus, Kirriemuir
1887 Duncan, Wm., Welltown, Coupar-Angus
1881 Duncan, W. G., Balkemback, Tealing, Dundee
1895 Durkie, Alex. F., Mill of Mains, Dundee
1887 Farquharson, Alex., Greenburn, Coupar-Angus
1894 Fenton, David, Kingennie, Dundee
1879 Ferguson, Jas., Balunie, Coupar-Angus
1893 Ferguson, James A., Architect, Glamis
1893 Fergusson, R. A., of Ethiebeaton, Dudhope Works, Dundee
1848 Forrest, James, jun., Kirriemuir
1879 Fullarton, Jas., Balgove, Coupar-Angus
1890 Gardiner, Thomas J., Banchory, Coupar-Angus
1890 Gilroy, George Alex., Broughty Ferry
1890 Gourlay, Henry, Balgay House, Dundee
1870 Graham, D. M., Auctioneer, Forfar
1890 Grainger, John, Pitcur, Coupar-Angus
1890 Grant, Alex., Forfar
1890 Grant, John, Craig Mills, Dundee
1881 Guild, Thomas, Herdhill, Kirriemuir
1890 Halkett, John Gilbert Hay, Balendoch, Meigle
1870 Hanning, J. J., 31 Tait's Lane, Dundee
1871 Harris, Wm., Innkeeper, Alyth
1878 Henderson, G. D. C., Com. R.N., of Invergowrie, Dundee
1890 Henderson, William, Milton of Collace, Coupar-Angus
1880 Hendry, William, Mains of Coul, Kirriemuir
1888 Hunter, Wm., Beech Tower, Broughty Ferry, Dundee
1894 Isles, Jas., Spirit Merchant, Dundee

Admitted
1890 Johnston, Alex., Castle of Mains, Dundee
1890 Johnston, John, 14 St Clement's Lane, Dundee
1890 Keiller, John Mitchell, of Morven, Binrock, Dundee
1890 Kidd, David, West Ardler, Meigle
1888 Kyd, Robert, Implement-maker, Coupar-Angus
1893 Laird, W. P., 78 Nethergate, Dundee
1894 Lindsay, Henry, Home Farm, Glamis
1890 Lyburn, John, Kinochtry, Coupar-Angus
1870 M'Farlane, William, 31 Benvie Road, Dundee
1865 M'Gavin, Robert, of Ballumbie, Dundee
1890 MacIntyre, Peter, Denfind, Monikie, Dundee
1890 M'Kay, Alexander, Mains of Auchterhouse, Lundie, Dundee
1890 Marshall, James Scott, Wynton Chemical Works, Dundee
1891 Martin, Robert, Baldovie, Kirriemuir
1890 Mathers, David, Hotel-keeper, Dundee
1894 Maxwell, David, Upper Drumgley, Forfar
1885 Menzies, W. D. Graham, Hallyburton, Coupar-Angus
1894 Mitchell, James, Nether Migvie, Kirriemuir
1886 Mitchell, William, Balnashanner, Forfar
1890 Murray, J. Douglas, 10 Windsor Terrace, Dundee
1893 Murray, John Kennedy, Crosstown, Forfar
1891 Murray, Joseph, Dryburgh, Lochee, Dundee
1887 Myles, Rob., Coilamy, Cortachy, Kirriemuir
1867 Nicol, T. Monro, Littleton, Kirriemuir
1891 Nicoll, William, Carsebank, Forfar
1894 Ogilvy, John, Lisden, Kirriemuir
1871 OGILVY, Sir Reginald H. A., of Inverquharity, Bart., Baldovan House, Dundee
1890 Pattullo, David, South Gask, Coupar-Angus
1885 Pattullo, William, 19 St Andrew Street, Dundee
1893 Pattullo, William, Fullarton, Meigle
1849 Powrie, James, of Reswallie, Forfar
1880 Primerose, A. G., Dock Street, Dundee
1868 Ralston, Andrew, Glamis House, Glamis
1876 Reid, George, Ladywell, Kirriemuir
1873 Reid, James, Kilmundy, Glamis
1879 Ritchie, R. B., Accountant, Dundee
1890 Robertson, Alexander, of Burnside, Forfar
1890 Robertson, Wm. Brown, Dudhope House, Dundee
1862 Rogers, James S., Rose Mill, Dundee
1881 Rogers, Wm., Ph.D., Rose Mill, Dundee
1881 Ross, Wm., North Drumglay, Forfar
1890 Scott, George C., The Retreat, Perth Road, Dundee
1894 Scott, Jas., Suttieside, Forfar
1882 Scott, Robert, 56 Dundee Road, Forfar
1888 Sharp, Andrew, 24 Springfield, Perth Road, Dundee
1890 Sharp, John, jun., Balmuir House, Dundee
1890 Shiell, John, Solicitor, Bank Street, Dundee
1890 Short, James, Royal Hotel, Coupar-Angus
1890 Sidey, James, Newhall, Coupar-Angus
1894 Sim, Jas., Kilnhill, Kirriemuir
1889 Smart, John B., Pitairlie, Monifieth, Dundee
1877 Smith, Thomas, Powrie, Dundee
1884 Smith, Thomas, Mains of Fowlis, Dundee

Admitted
1890 Spreull, Andrew, V.S., Yeaman Shore, Dundee
1894 Stewart, John, Novanbank, Tannadice
1893 Stewart, William, New Mill, Tannadice, Forfar
1891 Strachan, James, West Pilmore, Longforgan, Dundee
1867*†STRATHMORE, The Earl of, Glamis Castle
1890 Tasker, George, Arnbog, Meigle
1889 Tasker, William, Camno, Meigle
1890 Thoms, Thomas S., Benvie, Invergowrie, Dundee
1893 Thomson, David Couper, 'Courier' Office, Dundee
1881 Turnbull, George, Baldoukie, Tannadice
1880 Watson, Wm., Ochterlony Mains, Forfar
1881 Wedderspoon, George, Balgavies, Forfar
1868 White, John F., Craigtay, Dundee
1891 White, J. Martin, of Balruddery, Dundee
1861 Whitton, And., of Couston, Newtyle
1884 Whyte, Archibald, Spott, Kirriemuir
1870 Whyte, Archibald, jun., Nether Hayston, Forfar
1890 Whyte, James, Upper Hayston, Glamis
1871 Whyte, John, West Denoon, Glamis
1868 Whyte, William, Spott, Kirriemuir
1893 Whyte, Wm., jun., Spott, Kirriemuir
1881 Wilkie, James, Solicitor, Kirriemuir
1888 Willisher, George, Pitpointie, Auchterhouse, Dundee
1878 Wilson, T. Mackay, Solicitor, Kirriemuir
1890 Young, John, Balmyle, Meigle

## KINROSS.

1882 ADAM, Sir Chas. E., of Blairadam, Bart.
1861 Anderson, Robert H., Tillyrie Cottage, Milnathort
1893 Barclay, John, Pittendreich, Kinross
1868 Beath, David, Arlary, Milnathort
1873 Begg, R. Burns, Sheriff-Clerk, Kinross
1882 Beveridge, John, of Kinneston, Leslie, Fife
1884 Bogie, Major, Bank Agent, Kinross
1886 Ewing, Francis, Bank Agent, Milnathort
1884 Flockhart, Wm., of Annacroich, Kinross
1884 Greig, Andrew, of Holeton, Milnathort
1883 Greig, John, of Tillyrie, Milnathort
1885 Hepburn, John, V.S., Milnathort
1878 Mitchell, Jas., Aldie Castle, Fossoway
1882 Montgomery, H. Jas., of Hattonburn, Milnathort
1892 Morrison, J. B. B., of Finderlie, Kinross
1871 Reid, George, of Tillyrie, Milnathort
1881 Russell, T. Purves, of Warroch, Milnathort
1890 Simpson, James, of Mawcarse, Milnathort
1878 Simpson, Jas., North Lethans, Kinross
1884 Steedman, James, of Fruix, Kinross
1884 Steedman, Thos., Bank Agent, Kinross
1873 Terris, J., jun., Dullomuir, Blair Adam
1870 Tod, Thos. M., of West Brackly, Kinross
1884 Tod, Wm., of East Brackly, Kinross
1874 Waddell, George, Lassodie Mill Colliery, Blair Adam
1877 Walls, James, Lochran, Kinross
1891 Young, Robert, Sunnyside, Kinross

## PERTH

(EASTERN DIVISION).

1893 Adamson, James, Grange, Errol
1893 Allan, James, Implement Maker, Tibbermuir
1878 Allan, John, Culthill, Dunkeld
1887 Allan, William, Kinnon Park, Methven, Perth

Admitted
1874 Anderson, Alex., Berryhill, Dundee
1870 Anderson, Archibald Turnbull, Perth
1873 Anderson, Dr Arthur, C.B., Sunnybrae, Pitlochry
1871 Anderson, John A., St Albans, Perth
1878 Anderson, Peter, Duncaves, Fortingal
1871 Anderson, Robert, Balbrogie, Coupar-Angus
1890 Annand, David, Cotton of Craig, Glen Isla, Alyth
1860*†ATHOLL, The Duke of, K.T., Blair Castle, Blair Atholl
1841 ATHOLL, The Duchess Dowager of, Dunkeld
1870 Ballingall, A. H., W.S., Perth
1895 BALVAIRD, Lord, Scone Palace, Perth
1893 Baxter, Wm., jun., Tophead, Stanley
1869 Bayne, Lewis, Jeanie Bank, Old Scone, Perth
1879 Beattie, Jas., Rockdale Cottage, Perth
1887 Bell, James H., of Rossie, Forgandenny
1884 Bett, Thomas, Urlar, Aberfeldy
1873 Bisset, Thomas S., Blairgowrie
1884 Black, Captain, of Balgowan, Perth
1893 Boyd, James Laurence, of Glendouglie, Glenfarg
1883†BREADALBANE, The Marquis of, K.G., Taymouth Castle, Aberfeldy
1888 Brewster, James, Tarrylow, Balbeggie, Perth
1871 Brown, Peter, Milton of Luncarty, Redgorton
1877 Butter, Albert, Union Bank, Perth
1894 Caird, Dr J. Hay, Ballinloan, Rannoch
1871 Cairns, Robert, Bertha Park, Perth
1882 Calder, Jas., of Ardargie, Forgandenny
1888 Cameron, Donald, Roro More, Aberfeldy
1887 Cameron, Duncan, Kinloch-Rannoch
1892 Campbell, Alexander, Borland, Fernan, Killin
1887 Campbell, Lieut.-Col., General Prison, Perth
1879 Campbell, Duncan, Stronuich, Aberfeldy
1846 Campbell, J. L., of Achalader, Blairgowrie
1871 Chalmers, James, 11 Charlotte Street, Perth
1879 Chalmers, John, Westwood, Stanley
1890 Chisholm, Colin Edward, Grange of Elcho, Perth
1871 Chrystal, George, Engineer, Perth
1871 Clark, Robert, Taybank House, Errol
1881 Cowan, Walter, Kinmonth, Bridge of Earn
1899 Cox, Albert E., of Dungarthill, Dunkeld
1890 Cox, William Henry, yr. of Snaigow, Dunkeld
1860 Crawford, William, Pitlochry, Perth
1879 Dalgleish, Wm. Ogilvy, of Errol Park, Errol
1894 Dewar, John A., Lord Provost of Perth
1846 Dickson, John, W.S., Greenbank, Perth
1871 Doe, John, Errol
1893 Donaldson, Jas., Legerlaw, Coupar-Angus
1879 Dow, David, jun., Balmanno, Bridge of Earn
1865 Duff, James, 48 Glover Street, Perth
1878 Dunn, Wm., Kenmore Mains, Aberfeldy
1874 Fell, John Duncan, Flesher, Blairgowrie
1894 Fenwick, Jas., Kirkhill, Redgorton
1879 Ferguson, W. S., Pictstonhill, Perth
1879 Fergusson, Donald, Dalcapon, Ballinluig
1861 Fisher, Donald, The Hotel, Pitlochry
1881 Fleming, Rev. A., of Inchyra, Hamilton House, Perth
1892 Fotheringham, Walter Stewart, of Fotheringham and Murthly
1879 Fraser, John M., Auction Mart, Perth
1874 Galloway, Alex., C.E., Dirgarbh, Aberfeldy
1890 Galloway, David, Grain Merchant, Perth

Admitted
1884 Galloway, Thomas T., Magotland, Inchture, Perth
1881 Gammel, Colonel J. H. H., of Lothendy, Meikleour
1871 Geekie, R., of Baldowrie, Rosemount, Blairgowrie
1887 Gellatly, William, Balgowan, Perth
1871 Gibson, Charles, Pitlochry
1875 Gillespie, James J., St Colmes, Ballinluig
1873 Gold, Joseph, Murthly Farm, Perth
1887 Gow, Geo., Dunalastair Hotel, Rannoch
1881 Graham, A. G. Maxtone, yr. of Cultoquhey, Crieff
1848 Graham, J. Maxtone, of Cultoquhey, Crieff
1888 Grahame, John, Sheriff-Substitute, Murrayshall, Perth
1887 Grant, George, Tullyneddie, Blairgowrie
1870 Grant, John S., Tullymet, Ballinluig
1889 Grant, Robert, Bengarth, Blairgowrie
1880 Gray, George, of Bowerswell, Perth
1894 Gray, Thomas, Fingask, Rhynd, Perth
1861 Greig, T. Watson, of Glencarse, Perth
1895 Greig, Thomas, yr. of Glencarse, Perth
1871 Grimond, Alex. D., of Glenericht, Blairgowrie
1871 Haggart, Peter, Breadalbane Mills, Aberfeldy
1881 Hart, Andrew, Aberdalgie, Perth
1870 Hay, Alexander, Easter Cultmalundie, Perth
1862 Hay, Colonel Drummond, of Seggieden, Perth
1890 Haynes, George G., Aberfeldy
1894 Hollingworth, Thos., New Mains, Inchture
1893 Howieson, James, Rannagullzion, Blairgowrie
1894 Howison, Robert, East Inchmichael, Errol
1895 Hunter, John (of Hay & Co.), Fingask, Perth
1871 Hunter, Patrick, Waterybutts, Errol
1882 Hutcheson, Andrew, Beechwood, Perth
1893 Jackson, Thos. D., Live Stock Salesman, Perth
1884 Jameson, Martin, Fernhill, Perth
1852 Jameson, Melville, Solicitor, Perth
1880 Jamieson, Alexander, 31 Barossa Place, Perth
1880 Jamieson, John, 31 Barossa Place, Perth
1890 Japp, William, of Broomhall, Alyth
1871 Johnston, James, Cattle-dealer, Perth
1871 Johnston, Stewart J., Loanleven, Huntingtower, Perth
1893 Keay, Peter, Marybank, Herriotfield, Logie Almond
1881 Kerr, Thomas, Forehill, Caputh
1891 Kidd, George, Drumkilbo, Meigle
1878 Kincairney, The Hon. Lord, Dunkeld (6 Heriot Row, Edinburgh)
1877 Kinloch, Sir John G. S., of Kinloch, Bart., M.P., Meigle
1879 Kinnaird, Lord, Rossie Priory, Inchture
1884 Kinnear, Chas., Tarsappie, Perth
1853 Kinnoul, The Earl of, Dupplin Castle, Perth
1894 Kirk, J. M., 22 St John Street, Perth
1879 Kyd, George, Perth
1857 Latham, P. R., Taybank, Caputh, Dunkeld
1894 Leslie, Thomas, Kinloch Arms Hotel, Meigle
1879 Livingston, John, Balarchibald, Ballechin, Ballinluig
1884 Lumsden, J. D., Huntingtowerfield, Perth
1871 M'Cash, John, Grain Merchant, Perth

Admitted
1884 Macdiarmid, Donald, Bank of Scotland, Aberfeldy
1875 M'Diarmid, Duncan, Camusericht, Rannoch
1855 Macdonald, Archd. Burns, Perth
1887 Macdonald, Duncan, Comrie Farm, Aberfeldy
1890 M'Donald, James, City Mills, Perth
1880 Macdonald, Montague, of St Martins, Perth
1871 Macdonald, William, "The Athole," Pitlochry
1860 M'Dougall, Archd., Ardtalanaig, Perthshire
1871 M'Dougall, John, Goodlyburn, Perth
1874 Macduff, Alex., of Bonhard, Perth
1883 M'Gillewie, R., Union Bank, Dunkeld
1882 M'Gregor, Athole, Eastwood, Dunkeld
1872 Macgregor, Donald, Dalnabo Cottage, Ballinluig
1894 M'Gregor, Malcolm, Caledonian Road, Perth
1878 M'Intosh, James, Boatlands, Coupar-Angus
1862 Mackenzie, Sir Alex. M., of Delvine, Bart., Dunkeld
1895 Mackenzie, Capt., Balboughty, Perth
1890 Mackenzie, George A., Solicitor, Perth
1885 Mackenzie, R. W. R., Stormontfield, Perth
1873 Mackie, J. H. J., Invermay, Forgandenny
1879 M'Laren, Charles, Cally Lodge, Dunkeld
1858 M'Laren, John, Retreat House, Scone
1879 M'Laren, Wm., Pittendrigh, Meikleour
1880 MacLeish, Wm., Town-Clerk, Perth
1881 M'Leish, Dan., Wester Keillor, Methven
1877 M'Leish, G. S., Wester Drumatherty, Dunkeld
1884 M'Leish, James, Byres of Murthly, Perth
1890 M'Millan, David, Calvine, Struan
1892 M'Naughton, Alex., Manufacturer, Pitlochry
1871 M'Naughton, Wm., Avon Villa, Abbot Street, Craigie, Perth
1878 Macpherson, Allan, of Blairgowrie
1879 MacRitchie, David, of Easter Logie, Blairgowrie
1833†Mansfield, The Earl of, K.T., Scone Palace, Perth
1887 Marshall, James Burt, of Luncarty, Perth
1885 Marshall, Robert, Denmarkfield, Perth
1887 Martin, Andrew, Montabor, Kinnoull, Perth
1890 Martin, John Claude, Hilton, Perth
1884 Matthew, John M., yr. of Auchmague, Perth
1887 Maxwell, William, of Donavourd, Pitlochry
1895 Meiklejohn, T. N., Estates Office, Murthly
1841 Menzies, Fletcher Norton, Balmacneil, Ballinluig
1869 Menzies, Dr James, of Pitnacree, Ballinluig
1877 Menzies, Neil James, yr. of Menzies
1841 Menzies, Sir Robert, of Menzies, Bart., Farleyer, Aberfeldy
1893 Menzies, Robert, Millhaugh, Herriotfield, Logie Almond
1879 Menzies, Robert, Tirinie, Aberfeldy
1887 Menzies, Wm. J. B. Stewart, of Chesthill, Aberfeldy
1885 Middleton, Captain W. F., Baldarroch, Murthly
1893 Millar, James Robert, Flawcraig, Errol
1887 Millar, Robert H., of Blair Castle, Culross

Admitted
1871 Millar, Wm., Over Kinfauns, Perth
1890 Miller, George A., W.S., Perth
1893 Miller, William, jun., Kilspindie, Errol
1877 Mitchell, Hugh, Banker, Pitlochry
1882 Mollison, James, Ruthven, Meigle
1852 MONCREIFF, Col. Sir Alex., K.C.B., F.R.S., Bandirran, Perth
1888 Moncrieff, R. H., Potterhill, W.S., Perth
1889 MONCREIFFE, Sir Robt. D., of Moncrieffe, Bart., Perth
1879 MORAY, The Earl of, 14 Atholl Crescent, Edinburgh
1887 Morton, John, Muirton, Perth
1879 Morton, R. G., Engineer, Errol
1883 Munro, Chas., Union Bank, Aberfeldy
1871 Murray, C. A., Taymount, Stanley
1879 Murray, David, Tyngeat, Pitlochry
1879 Nairne, T. G., Dunsinnan, Perth
1874 Nairne, William, of Dunsinnan, Perth
1844 Ogilvy, Lieut.-Col. Thos. W., of Ruthven, Meigle
1871 Panton, John, of Dalnagairn and Carsie, Blairgowrie
1880 Paton, Jas., jun., Obney, Bankfoot
1893 Paton, Wm. B., Monorgan, Longforgan
1892 Paterson, Chas. J. G., of Castle Huntly, Longforgan
1893 Pattullo, T. M., Ashmore Farm, Blairgowrie
1884 Philp, Alexander, Mains of Duncrub, Dunning
1871 Pirrie, James P., Coachbuilder, Perth
1891 Pitcaithly, Geo., West Dron, Bridge of Earn
1877 Pople, George, Newhouse, Perth
1867 Pople, H. W., Royal British Hotel, Perth
1861 Pople, J. B., of Newhouse, Letham House, Huntingtower, Perth
1871 Pullar, Robert, of Tayside, Perth
1884 Rae, W. A., Kingswood, Murthly
1871 RAMSAY, Sir James H., of Bamff, Bart., Alyth
1854 Rattray, Lieut.-Gen. J. C., of Craighall, C.B., Blairgowrie
1874 Rattray, Dr J. C., of Coral Bank, Blairgowrie
1894 Rhind, John, Wester Kinloch, Blairgowrie
1890 Richardson, Colonel Edmund R. Stewart, of Ballathie, Stanley
1861 Richmond, John, Dron, Bridge of Earn
1871 Richmond, T., Hilton, Perth
1892 Ritchie, George, of Hill of Ruthven (The New Club, Tay Street, Perth)
1879 Robertson, Alex., Ballechin, Ballinluig
1893 Robertson, Daniel, Mains of Fordie, Dunkeld
1879 Robertson, Don., Blackhill, Ballinluig
1880 Robertson, E. W., of Auchleeks, Blair Athole

Admitted
1881 Robertson, James, Taymount, Stanley
1851 Robertson, J. S., of Edradynate, Ballinluig
1876 Robertson, J. S., yr. of Edradynate (Colquhalzie, Auchterarder)
1864 Robertson, John, Old Blair, Blair Athole
1879 Robertson, Wm., jun., of Craiglochie, Perth
1883 Robertson, Wm., Potato Merchant, Perth
1879 Robertson, Wm., Engineer, Perth
1883 Rollo, James A., County Club, Perth
1871 Roy, Thomas, Craigclowan, Perth
1887 Sandeman, Col. F. S., Stanley House, Stanley
1891 Sandeman, Lt.-Col. Geo. G., of Fonab, Pitlochry
1879 Scott, John, Gallin Cottage, Aberfeldy
1883 Scrimgeour, Peter, Balboughty, Perth
1891 Seaton, Donald, Cronan, Coupar-Angus
1890 Sellar, James T., W.S., Perth
1893 Sidey, David, Middle Gourdie, Dunkeld
1889 Sinclair, John, Greenhill, Dunning
1859 Small, James, of Dirnanean, Pitlochry
1887 Smart, James, Architect, Perth
1891 Smith, James, Cranley, Meikleour
1876 Smythe, Colonel David M., of Methven, Perth
1889 Speedie, Matthew, Pitversie, Abernethy
1881 Speid, James, Forneth, Dunkeld
1890 Stead, W. F., Ballindean House, Inchture
1880 Steel, Adam, yr. of Blackpark, Perth
1880 Steuart, John, of Ballechin, Tullypowrie
1891 Stevens, A. B., Mains of Kilgraston, Bridge of Earn—*Free Life Member*
1893 Stewart, Alex. Blair, Balnakeilly, Pitlochry
1889 Stewart, Daniel, Muirhall, Perth
1870 Stewart, Donald, Clachan, Calvine
1881 Stewart, D. D., Castlehill, Inchture
1888 Stewart, H. D., Strathgarry, Blair Athole
1871 Stewart, James, Blair Athole
1876 Stewart, James, Butcher, Coupar-Angus
1883 Stewart, J. F., Newmill, Stanley
1893 Sutherland, William, Peel, Tibbermuir
1878 Talbert, Peter, Glenericht, Blairgowrie
1881 Thomson, Thos., Cordon, Abernethy
1894 Webster, Jas. A., Banker, Meigle
1881 Wedderspoon, Thos., Live Stock Salesman, Perth
1862 White, Dr Francis, Perth
1892 Whitson, W., Isla Park, Coupar-Angus
1871 Whyte, Angus, Kipney Cottage, Harrietfield, Logiealmond, Perth
1884 Whyte, Wm., Muirhead, Forgandenny
1873 Wood, C. L., of Freeland, Forgandenny
1894 Wynd, David, Newbigging, Errol
1894 Young, Robert, Dunkenny, Meigle

# 3.—STIRLING DISTRICT.

EMBRACING THE

COUNTIES OF CLACKMANNAN, DUMBARTON, PERTH (WESTERN DIVISION), AND STIRLING.

## CLACKMANNAN.

Admitted
1880 Alexander, James, Inch of Ferryton, Clackmannan
1887 Alexander, William, Loanside, Clackmannan
1871 Allan, William, Grassmainston, Clackmannan
1887 Arrol, Archd. T., Mill Grove, Alloa
1873†BALFOUR of Burleigh, Lord, Kennet, Alloa
1889 Blair, Charles, Glenfoot, Tillicoultry
1883 Bonallo, W. C., Harvieston Estate Office, Dollar
1891 Cairns, John, Dollarbank, Dollar
1872 Christie, John, of Cowden, Dollar
1891 Clarke, John, Meadowhill, Clackmannan
1850 Connal, Wm., Solsgirth, Dollar
1877 Crawford, John, High Street, Alloa
1872 Dewar, James, Ballilieck, Dollar
1880 Dickie, Robert, Westertown, Dollar
1892 Dobie, W. H., of Dollarbeg, Dollar
1893 Donaldson, Robert, Tullibody, Alloa
1873 Drysdale, David, Lorns Hill, Alloa
1890 Drysdale, William, King o' Muirs, Alloa
1873 Fisher, Donald, Jellyholm, Alloa
1888 Galashan, Alfred, Saddler, Alloa
1873 Galashan, Charles C., Saddler, Alloa
1893 Gall, William, King Street, Alloa
1874 Haig, J. R., of Blairhill, Dollar
1880 Haig, Robert, Dollarfield, Dollar—*Free Life Member*, 1887
1875 Haig, W. J., of Dollarfield, Dollar
1878 Hare, Colonel, Blairlogie, Stirling
1858 Henderson, Robert, Nether Carsebridge, Alloa
1893 Jeffrey, Robert, Meadowend Farm, Clackmannan
1892 Kinross, D. A., Hillend, Clackmannan
1864 Kinross, John, Hillend House, Clackmannan
1874 Knox, Robert, Woodside, Cambus, Alloa
1888 Lang, James, Aitkenhead Farm, Clackmannan
1889 Leishman, William, of Broomrigg, Dollar
1882 M'Gregor, Alex., Craigton, Clackmannan
1885 M'Laren, J. T., Kennet, Alloa
1891 M'Laren, William, Longcarse, Alloa
1893 M'Leod, Geo., Land-Steward, Harvieston Castle, Dollar
1893 M'Nab, Alexander, Middleton Kerse, Menstrie
1873 Macnab, James, of Middleton Kerse, Menstrie
1884 Macnab, John, Glenochil House, Menstrie
1890 Mair, William, Gartary, Clackmannan
1890 MAR and KELLIE, The Earl of, Alloa Park, Alloa
1893 Millar, John M., Sheardale Haugh, Dollar
1848 Mitchell, Andrew, Alloa
1878 Moir, James M'Arthur, of Hillfoot, Dollar
1893 Norval, Alex., Solicitor, 38 High Street, Alloa
1875 Orr, James, of Harvieston, Dollar
1893 Peebles, James, Land-Steward, Naemoor, Rumbling Bridge
1869 Robertson, Rev. A. Irvine, Clackmannan
1878 Simpson, James, Tower, Alloa
1879 Wilkie, David, Bridge Street, Dollar
1873 Young, George, Auctioneer, Dollar
1879 Younger, George, Brewer, Alloa
1889 Younger, James, Arns Brae House, Alloa

## DUMBARTON.

1859 Anderson, John, Dullatur, Cumbernauld
1873 Anderson, John, Merkins, Alexandria
1872 Breingan, A., Merchant, Helensburgh
1894 Brock, Hugh B. P., Auchenheglish, Alexandria, N.B.
1857 Buchanan, Alex. Norwood, Milngavie
1873 Buchanan, David, Garscadden Mains, Bearsden
1873 BUCHANAN, Sir Geo. H. Leith, of Ross, Bart., Alexandria
1861 Burns, J. W., of Kilmahew, Cardross
1857 Calder, James, Colgrain, Cardross
1888 CAMPBELL, Lady, of Garscube, Maryhill
1817 Campbell, J., of Tillichewan, Alexandria
1888 Campbell, J. A., Broomley, Alexandria
1880 Campbell, Wm. Middleton, of Colgrain, Dumbarton (23 Rood Lane, London)
1873 Colquhoun, George, Shemore, Luss
1872 COLQUHOUN, Sir James, of Luss, Bart., Rossdhu, Luss
1881 Cullen, William, Barbegs, Croy
1857 Dalrymple, James, of Woodhead, Kirkintilloch
1868 Douglas, Archd. C., of Mains, Milngavie
1892 Douglas, John, Braes o' Yetts, Kirkintilloch
1881 Duncan, James, yr. of Auchendavie, Kirkintilloch
1881 Duncan, John, Auchenbee, Croy
1881 Duncan, Thos., Dullater, Cumbernauld
1857 Ewing, Alexander Crum, of Keppoch Cardross

Admitted
1880 Findlay, R. E., of Boturich, Alexandria
1872 Galbraith, John, Edentaggart, Luss
1893 Galloway, Thomas, of Glenlorum House, Bearsden
1863 Gilmour, John, of Mount Vernon, Row
1881 Gilmour, William E., Woodbank, Alexandria
1881 Graham, George, jun., Easter Board, Gartshore, Croy
1861 Hain, David, Barremman, Clynder
1864 Jack, John S., Adrigbank, Milngavie
1873 Jardine, Andrew, Ballemenoch, Helensburgh
1888 Kennedy, James, Chesters, Bearsden
1854 Lang, William, Helensburgh
1893 Leith, Alex. Wellesley, yr. of Ross, Dumbartonshire (Western Club, Glasgow)
1875 Lumsden, James, of Arden, Alexandria
1883 M'Auslan, Peter, Letrualt, Row
1888 MacBrayne, David, yr. of Glenbranter, Auchenteil, Helensburgh
1873 Macdonald, John, Boquhanran, Dalmuir
1892 M'Farlan, Coll Jas. Turner, Stronafyne, Arrochar
1831 M'Farlan, John, Faslane, Garelochhead
1892 Macfarlan, Parlan, Faslane, Garelochhead
1873 M'Farlane, Colin, Strone, Glenfruin, Garelochhead
1873 M'Farlane, Duncan, Greenfield, Garelochhead
1872 M'Indoe, James, Glenmolachan, Luss
1865 Mackenzie, John, Letter Farm, Cove
1838 Mackenzie, Robert D., of Caldarvan, Alexandria
1878 Mackinlay, William, Ardoch, Cardross
1873 Maclachlan, Colin, Woodend, Helensburgh
1888 M'Lean, Thos., Banker, Alexandria
1872 M'Murrich, James, Stuckievullich, Arrochar
1873 M'Nab, Donald, Duchlage, Luss
1882 M'Nab, Robert, Luss Hotel, Loch Lomond
1876 M'Nair, Robert, Westertown, New Kilpatrick
1884 Macpherson, A. H., Tarbet Hotel, Loch Lomond
1867†Martin, John M., of Auchendennan, Alexandria, N.B.
1884 Millar, James, Firkin, Arrochar
1856 Milne, J., Union Bank of Scotland, Helensburgh
1863 Murray, David, LL.D., Moore Park, Cardross
1881 Park, Alex., Gartshore, Croy, Glasgow
1870 Robertson, R. W., Rockingham, Kilcreggan
1894 Weir, James, Woodilee Farm, Lenzie—*Free Life Member*
1882 Whitelaw, Alex , of Gartshore, Croy
1853 Wilson, James, Luss Estates Office, Helensburgh
1836 Young, James, Broadholm, Duntocher

## PERTH

(Western Division).

1883 Anderson, A. H., Kippendavie Estate Office, Dunblane
1879 Anderson, James, Garbal Farm, Crianlarich, Stirling
1857 Ballingall, D., Factor, Blairdrummond
1873 Barty, Jas. W., Solicitor, Dunblane
1864 Blair, James, Aberfoyle
1890 Buchanan, John, Inverardran, Crianlarich
1861 Cairns, William, Belhie, Auchterarder
1871 Carrick, Charles, Baad, Stirling

Admitted
1872 Carrick, T. A., Easter Cambusdrennie, Stirling
1881 Christie, Gilbert, Auchlyne, Killin
1882 Cochran, Wm., Overdale, Dunblane
1874 Colquhoun, Rev. J. E. Campbell, Ledcameroch, Dunblane
1882 Cox, George A., of Invertrossachs, Callander
1882 Cox, James C., Invertrossachs, Callander
1879 Craig, John, Innergeldie, Comrie—*Free Life Member*
1880 Craig, William, Gwydyr House, Crieff—*Free Life Member*
1883 Crawford, Thos., Dumawhance, Crieff
1881 Crerar, Alex., Straid Cottage, Callander
1871 Curr, Henry, Pitkellony House, Muthill
1894 Dick, Jas., Ballinton, Blair Drummond
1894 Dougal, James, Blaircessnock, Port of Monteith
1879 Dow, James, Clathybeg, Auchterarder
1869 Drummond, Col. Home, of Blairdrummond, Stirling
1890 Duncan, Hector Macduff, yr. of Damside, Auchterarder
1876 Dundas, Chas. Henry, Dunira, Crieff
1882 Dundas, Colin M., Commander R.N., of Ochtertyre, Stirling
1894 Dunn, Jas., Inverardoch Mains, Doune
1864 Edington, Peter, Thornhill, Muthill
1873 Edmond, William, Kippendavie Mains, Dunblane
1887 Fletcher, Angus, Auchtertyre, Tyndrum
1876 Forbes, Arthur Drummond, of Millearne, Auchterarder
1861 Gardiner, Robert, of Rottearns, Henhill, Forteviot
1884 Græme, Robert, of Garvock, Bridge of Earn
1894 Graham, Donald, of Airthrey Castle, Bridge of Allan
1859 Grieve, Michael, Wolseley Park, Callander
1857 Grieve, Robert, Glenfalloch, Crianlarich
1869 Hamilton, J. B. B., of Arnprior, Callander
1846 Hamilton, J. B., of Leny, Callander
1873 Hart, Wm., Nether Garvock, Dunning
1889 Holmes, James, Auchinteck, Dunblane
1884 Johnston, J. S., Fintalich, Muthill
1878 Kinross, Andrew, Hungryhill, Dunblane
1861 Kirk, James, Kaimknow, Muckhart
1874 Kirkland, Major-General, of Wester Fordell, Milnathort
1882 M'Ara, Alex., Culdees, Muthill
1887 M'Callum, Wm. R., Ballig, Crieff
1858 M'Diarmid, D. A., Rockwood, Killin
1881 Macdonald, John M. S., of Monachyle, Lochearnhead
1893 M'Dougall, John, Benglass Farm, Crianlarich
1890 MacEwen, Daniel, Merchant, Callander
1888 M'Ewen, John, Cambushinnie, Dunblane
1894 M'Ewen, John, Land-Steward, Thornhill, Methil
1891 Macfarlane, Charles, East Brackland, Callander
1865 M'Innes, Duncan, Milton Cottage, Crieff
1893 Mackay, John, Brucehill of Cardross, Port of Monteith
1881 Mackie, Peter, East Kirkton, Auchterarder
1872 Maclachlan, James, Doune Lodge, Doune
1859 M'Laren, J., Brae of Monzievaird, Crieff
1888 M'Laren, W. D., Drummore, Blairdrummond
1861 MacLean, Duncan, Belnollo, Crieff
1873 M'Murrich, Peter, Glen Allan, Dunblane
1873 M'Nab, John, M'Nab House, Callander
1871 M'Naughton, John, Inverlochlairg, Balquhidder

Admitted
1879 M'Naughton, Robert, of Cowden, Comrie
1857 M'Niven, A., Innishewan, Killin
1871 M'Rosty, James, Solicitor, Crieff
1872 Marshall, W. H., of Callander (25 Heriot Row, Edinburgh)
1879 Menzies, James, Finlarig, Killin
1853 Millar, Hew, Newstead, Crieff
1879 Millar, John, Lochland, Crieff
1869 Moray, Lieut.-Colonel H. D., of Blairdrummond, Stirling
1882 Morries-Stirling, J. M., Gogar House, Stirling
1882 Moubray, John James, of Nacmoor, Dollar
1853 Murdoch, John Burn, of Gartincaber, Blairdrummond, Stirling
1880 Murray, Anthony G., of Dollerie, Crieff
1873 Murray, John, Munnieston, Thornhill, Stirling
1862 MURRAY, Sir Patrick Keith, of Ochtertyre, Bart., Crieff
1894 Newbigging, Alex., of Dalchonzie, Comrie
1892 Pagan, John S., Braendam, Thornhill, Perthshire
1882 Paterson, John, Kirkton, Tyndrum
1864 Reid, Walter, Craigarnhall, Bridge of Allan
1861 Robertson, David, Allan Hill House, Dunblane
1864 Robertson, D. G., of Torrie, Callander
1857 ROLLO, Lord, Duncrub House, Dunning
1883 ROLLO, The Hon. The Master of
1871 Ross, James E., Abercairny, Crieff
1890 Sharp, George R., Bardrill, Blackford
1881 Sharp, Jas. R., Viewfield, Blackford
1883 Sharp, John, South Forr, Crieff
1882 Sheppard, Rev. H. A. G., of Rednock, Port of Monteith
1870 Speir, R. T. A., Culdees Castle, Muthill
1875 Stark, M. C., Westerton Farm, Doune
1877 Stewart, Duncan, Callander
1881 Stewart, Duncan, Monachyle, Callander
1888 Stewart, Col. John, of Ardvoirlich, R.A., Lochearnhead
1865 Stewart, John, Bochastle, Callander
1882 Stewart, Joseph, Crianlarich, Stirling
1873 Stewart, Robert, Broom, Auchterarder
1889 Stirling, Archd., of Keir, Dunblane
1889 Stirling, James, Whiteston, Braco
1879 Stirling, Col. Patrick, of Kippendavie, Dunblane
1889 Stirling, T. Graham, of Strowan, Crieff
1885 Thomson, Samuel, Home Farm, Lanrick Castle, Doune
1880 Tress, George Russell, Callander
1882 Wallace, John, of Glassengall, Dunblane
1885 Watters, Thomas, Glenample, Lochearnhead
1894 White, Harry, Stronvar, Lochearnhead
1861 Williamson, Col. D. R., of Lawers, Crieff
1861 Wilson, Alexander, Alford House, Dunblane
1875 Wilson, John, Lecropt, Bridge of Allan
1870 Young, Wm. S., Keir Mains, Dunblane

## STIRLING.

1890 Adam, J. Denovan, Craigmill House, Stirling
1861 Aitken, John G., Southfield, Stirling
1878 Aitkenhead, Wm., Roughlands, Carron
1875 Baird, Hugh, Auchenbowie House, Bannockburn
1864 Bayne, John, Builder, Bridge of Allan
1876 Best, John, Inveravon, Polmont
1877 Binnie, Thomas, Auction Mart, Falkirk
1890 Blackburn, Adam, Killearn House, Glasgow

Admitted
1882 Blair, Robert, Inversnaid Hotel, Loch Lomond
1886 Bolton, Edwin, West Plean, Bannockburn
1858 Bolton, J. C., of Carbrook, Larbert
1888 Brown, Charles, Kerse Estate Office, Falkirk
1892 Brown, James, Queen's Hotel Stables, Bridge of Allan
1882 Brown, John, Brownville, Kilsyth
1882 Brown, John A. H., of Quarter, Dunipace
1854 Buchanan, Alexander, Whitehouse, Stirling
1877 Buchanan, D. M. B., of Boquhan, Killearn
1877 Buchanan, John, Gartness, Killearn
1876 Buchanan, Robert, Blairquosh, Strathblane
1876 Buchanan, Robt., Letter Farm, Killearn
1869 Bulloch, Archibald, Milliken, Maryhill
1882 Buntine, J. R., Sheriff-Subt., Stirling
1891 Cairns, William, Balquharn, Menstrie
1882 Campbell, Capt. Henry J. Fletcher, R.N., Boquhan, Kippen, Stirling
1878 Christie, James, Coxethill, St Ninians
1882 Couper, James, Craigforth, Stirling
1857 Dalgleish, John J., Brankston Grange, Bogside Station, Stirling
1894 Dempster, John, Logie Cottage, Airthrey, Bridge of Allan
1864 Dewar, A., Arnprior, Kippen
1864 Dewar, Peter, King's Park, Stirling
1864 Donie, J. R. L., Polmaise, Stirling
1890 Drummond, James W., Seed and Nursery Establishment, Stirling
1891 Drysdale, John, Fairfield, Kippen
1875 Duncan, A. R., Blairquosh, Strathblane
1885 Duncan, J. Dalrymple, Meiklewood, Stirling
1869 Edmond, David, of Ballochruin, Balfron
1881 Edmond, John, Galamuir, Bannockburn
1873 Edmond, Wm., Hillhead of Catter, Drymen
1889 EDMONSTONE, Sir Archd., of Duntreath, Bart., Colzium, Kilsyth
1862 Erskine, H. D., of Cardross, Stirling
1882 Ewing, A. E. Orr, of Ballikuirdin, Killearn
1890 Fisher, Daniel, Ballamenach, Bucklyvie
1864 Fleming, James, Carmuirs, Falkirk
1860† Forbes, William, of Callendar, Falkirk
1893 Fotheringham, Robt., Southfield, Kippen Station
1888 Fraser, John, Balfunning, Drymen
1892 Fraser, William L., of Arngibbon (24 Belhaven Terrace, Glasgow)
1880 Galbraith, J., Croy Cunningham, New Killearn Station
1873 Galbraith, T. L., Town-Clerk, Stirling
1894 Graham, Donald, of Airthrey, Bridge of Allan
1894 Graham, Donald N., Airthrey Castle, Bridge of Allan
1894 Graham, Jas. D., Airthrey Castle, Bridge of Allan
1873 Gray, Andrew, West Plean, Bannockburn
1873 Gray, James, Kersie Mains, Stirling
1891 Gray, James, jun., Birkenwood, Gargunnock
1872 Guild, And., Rhoders, Alva
1881 Hamilton, Alex., Commercial Bank, Stirling
1859 Hamilton, W. F., The Elms, Lauriston, Falkirk
1868 Hamilton, C. H., of Dunmore Park Larbert
1858 Hannay, John, of Cairnhill, Stirling
1876 Hannay, Robert, Bridge of Allan
1878 Hay, James S., Clydesdale Bank, Falkirk

Admitted
1873 Henderson, A. W., Bridge of Allan
1877 Henderson, William, of Redford, Linlithgow
1864 Inglis, John, Kepdarroch, Gargunnock
1891 Inglis, Robt., Patrickstone, Gargunnock
1881 Jaffray, William, Broomridge, St Ninians
1877 Jardine, Wm., Bogside, Fintry
1884 Kay, Andrew, Little Kerse, Kippen
1875 Kay, Charles, Mill Farm, Gargunnock
1881 Kay, Robert, Mains Farm, Gargunnock
1878 Ker, T. Ripley, of Dougalston, Milngavie
1868 King, C. M., Antermony House, Milton of Campsie
1857 King, Sir James, of Campsie, Bart., Bothwell Castle, Bothwell
1894 Kinross, Henry (James Gray & Co., Seedsmen), Stirling
1864 Lang, John, Beild, Gargunnock
1869 Learmonth, T. L., of Park Hall, Polmont
1884 Learmonth, Wm., Bowhouse, Grangemouth
1891 Lowe, P. R., Fernfield, Bridge of Allan
1885 Luke, John, Headswood, Denny
1857 Macadam, John, Blairo'er, Drymen
1873 M'Alpine, James, Springfield, Stirling
1873 M'Caull, Peter, Knockhill, Bridge of Allan
1888 Macdonald, Donald, Herbertshire Castle, Denny
1857 M'Farlan, Lieut.-Col. John W., of Ballencleroch, Campsie Glen
1894 M'Farlan, Parlan, Shore Wharf, Stirling
1891 Macfarlane, James, Oxhill, Bucklyvie
1891 Macfarlane, Parlane, Darnley House, Queen's Road, Stirling
1886 Macfarlane, Robt. C., West Carse, Stirling
1864 M'Indoe, Robert, Knowehead, Campsie
1891 M'Keich, William, Woodend, Bucklyvie
1889 Mackenzie, Robert, yr. of Caldarvan, Westerton, Bridge of Allan
1891 M'Kerracher, Daniel, Raploch, Stirling
1893 Mackison, John, Hillhead Farm, Thornhill, Stirling
1873 M'Lachlan, Archibald, 32 Queen Street, Stirling
1887 M'Laren, D., Cornton, Bridge of Allan
1891 M'Laren, James, Bandeath, Stirling
1867 Maitland, Sir James, of Barnton, Bart., Sauchie Burn, Stirling
1880 Malcolm, W. T., Dunmore, Airth Station, Stirling
1882 Melville, John H., Eriden, Falkirk
1890 Mitchell, David, Millfield, Polmont
1891 Mitchell, William, Blackdub, Stirling
1890 Moir, Alastair E. Graham, of Leckie, Gargunnock
1881 Moir, Alex., Nether Carse, Gargunnock
1876*†Montrose, The Duke of, Buchanan Castle, Drymen
1876 More, John, Fordhead, Kippen
1873 Morrison, James M., Banker, Stirling
1880 Morton, David, 1 Pitt Terrace, Stirling
1881 Murray, Capt. A. B., Beechcroft, Stirling
1861†Murray, James, Catter House, Drymen
1890 Murray, J. Campbell, Blairquhosh, Strathblane
1863 Murray, Lieut.-Col. John, of Polmaise, Stirling
1873 Nimmo, Alex., of West Bank, Falkirk
1852 Nimmo, Matthew, Baad, Stirling
1890 Paterson, James, Burnbank, Stirling
1882 Paterson, Robert, Hill of Drip, Stirling
1873 Paton, John, of Viewforth, Stirling
1873 Paton, Robert, West Drip, Stirling
1873 Patrick, James, Queenzieburn, Kilsyth

Admitted
1891 Paul, Walter, Laighpark, Milngavie
1889 Peat, John, Manor, Blairlogie, Stirling
1864 Philp, Robert, Royal Hotel, Bridge of Allan
1881 Pollock, J. J., of Auchinedcn, Strathblane
1891 Provan, John, Drum of Kinnaird, Larbert
1887 Pullar, Edmund, Coneyhill House, Bridge of Allan
1883 Rankin, Robert, Inchterf, Kirkintilloch
1868 Rankine, R. W., Rosebank, Falkirk
1891 Rawding, George, Bridgehaugh, Stirling
1880 Reid, Andrew, Haining Valley, Linlithgow
1882 Rennie, James, Corrie, Kilsyth
1882 Risk, James, Drumbrae, Bridge of Allan
1852 Ritchie, Wm., West Plean, Stirling
1855 Robertson, John, Benview, Falkirk
1873 Sands, James, Greenfoot, Gargunnock
1881 Scott, Rev. John, Camelon Manse, Falkirk
1884 Scott, Thomas, South Woodend, Bonnybridge
1872 Scoular, John, Crook, Stirling
1864 Sheriff, John Bell, Carronvale, Larbert
1881 Slessor, Rev. Alex., The Manse, Balfron
1857 Smith, Adam, Lochlands, Larbert
1893 Smith, James Kemp (Messrs Kemp & Nicholson), Stirling
1864 Smith, Robert, of Brentham Park, Stirling
1889 Speedie, John C., Rockdale, Stirling
1862 Stark, Ralph, of Summerford, Falkirk
1881 Struart, Sir Alan H. Seton, of Touch, Bart., Stirling
1882 Stevenson, John, Gateside, Denny
1851 Stewart, Jas. Ross, Meiklewood, Stirling
1879 Stewart, M. H. Shaw, of Carnock, M.P., Larbert
1868 Stirling, Sir C. E. F., of Glorat, Bart., Milton of Campsie
1857 Stirling, Major G., of Craigbarnet, Lennoxtown
1867 Stirling, James, of Garden, Kippen
1865 Stirling, Col. John S., of Gargunnock, Stirling
1881 Stirling, Robert, Pendreich, Bridge of Allan
1873 Taylor, James, Buchanan, Drymen
1890 Taylor, R., Craighead, Blairdrummond, Stirling
1877 Taylor, Robert, Solicitor, Stirling
1879 Thomson, James, Coach Works, Stirling
1873 Thomson, William, Nyaad, Stirling
1881 Turnbull, Jas., Carnock Smithy, Larbert
1875 Ure, George, Wheatlands, Bonnybridge
1875 Ure, George R., Hope Park, Bonnybridge
1874 Ure, William, Bogton, Larbert
1873 Walls, Robert, Kerse Mills, Stirling
1890 Waters, J. O. Dun, of Craigton, Balfron
1877 Watson, John, Skipperton, Denny
1871 Waugh, Allan, Avonbridge, Falkirk
1864 Wilson, Alexander, Bannockburn House, Bannockburn
1881 Wilson, David, jun., of Carbeth, Killearn
1864 Wilson, E. L., Bannockburn
1859 Wilson, John, of Auchineck, Killearn
1881 Wilson, William, Bannockburn House, Bannockburn
1891 Wilson, William Ralph, Hill Park, Bannockburn
1891 Yellowlees, Robert, Provost of Stirling
1867 Young, Andrew, 4 Clarendon Place, Stirling
1879 Young, John, Cobblebrae, Carron
1873 Young, William Taylorton, Stirling

# 4.—EDINBURGH DISTRICT.

EMBRACING THE

COUNTIES OF EDINBURGH, HADDINGTON, AND LINLITHGOW.

## EDINBURGH.

Admitted
1878 Adam, Robert, City Chamberlain, Edinburgh
1859 Ainslie, David, of Costerton, Blackshiels
1848 Ainslie, John, Hillend, Lothianburn
1865 Aitchison, Lieut.-Col., of Drummore, Musselburgh
1877 Aitken, Dr A. P., 8 Clyde Street
1854 Aitken, James, Fairhaven, Eskbank
1854 Aitken, T., 11 Hope Street, Portobello
1860 Aitken, T., 5 Grosvenor Crescent
1889 Alexander, A., 34 St Andrew Square
1878 Allan, John, 22 St Albans Road
1892 Allan, Thomas, Clifton, Mid-Calder,
1893 Allison, James, Claylands, Ratho
1881 Amour, John, Cramond Bridge
1877 Anderson, Charles, 377 High Street
1884 Anderson, J. R., W.S., 52 Palmerston Place
1884 Anderson, R. K., 377 High Street
1881 Anderson, W. M., Pirntaton, Stow
1873 Andrew, Robert, 8 Haymarket Terrace
1855 Archbald, T., of Viewbank, Lasswade
1876 Archbald, T. B., 36 Craigmillar Park
1869 Archibald, James, Overshiels, Fountainhall
1869 Archibald, John, Overshiels, Fountainhall
1887 Armstrong, W. J., 57 Manor Place
1877 Auld, Peter, 21 Millerfield Place
1894 Babington, William, 81A George Street, Edinburgh
1893 Bailey, Col. F., Professor of Forestry, Edinburgh University, 7 Drummond Place
1894 Baird, Archibald, M.R.C.V.S., 40 York Place
1876 Baird, Colin C., V.S., Clyde Street
1843 Baird, Sir James Gardiner, of Saughton Hall, Bart., 9 Learmonth Terrace
1877 Baird, Jn. W., 7 Union Street
1870 Balfour, Professor I. B., Inverleith House
1861 Bathgate, James, Middleton Lime Works, Gorebridge
1875 Bayley, George, 7 Randolph Crescent
1882 Belfrage, A. J., 3 Durham Road, Portobello
1871 Belfrage, A. W., C.E., 1 Erskine Place
1849 Belfrage, J., 40 Craigmillar Park
1895 Bell, David, 6 Bank Street, Leith
1893 Bell, John Dalrymple, of Clifton Hall, Ratho
1895 Bernard, John Mackay, 25 Chester St.
1877 Bertram, D. N., St Katherine's Works, Sciennes
1891 Black, A. D. M., W.S., 28 Castle Street
1862 Blackwood, William, 45 George Street
1874 Blair, John, W.S., 9 Ettrick Road
1879 Blair, Patrick, W.S., 19 Ainslie Place ]

Admitted
1861 Blues, Andrew A., 8 North Mansion House Road
1846 Borthwick, John, of Crookston, Heriot
1857 Brockley, Robert M., Gourlaw, Rosewell
1848 Brodie, James C., 6 Dean Terrace
1877 Brodie, Sir Thomas D., of Idvies, Bart., W.S., 9 Ainslie Place
1890 Brodie, William Alex. G., 15 Rutland Square
1877 Brown, James, Spittal, Penicuik
1881 Brown, Richard, C.A., 23 St Andrew Square
1892 Brown, Robert, Hillhouse, Kirknewton
1882 Brown, Wm., Currievale, Currie
1877 Bruce, E., 26 Greenside Place
1885 Brunton, Wm., 4 Bernard Street, Leith
1878 Bryce, And., Craigentinny, Edinburgh
1894 Bryden, Robert, 55 George Street
1853*†Buccleuch and Queensberry, The Duke of, K.T., Dalkeith House, Dalkeith
1880 Buchan, Alex., LL.D., 42 Heriot Row
1882 Buchanan, Ben., Springbank, Corstorphine
1892 Buchanan, Charles, Land Steward, Penicuik
1872 Buchanan, John, C.E., 24 George Street
1894 Buchanan, Robert, Livingston Mill, Livingston, Mid-Calder
1884 Burn, C. M. P., Prestonfield House, Edinburgh
1877 Burnett, A. E., 37 Drummond Place
1838 Burnley, W. F., 24 Ainslie Place
1867 Burton, J. Tait, of Toxside, Gorebridge
1884 Byres, Wm., Baadsmill, West Calder
1878 Caird, Alex. M'Neel, 73 Inverleith Row
1887 Cairns, Wm., Dairyman, Fountainbridge
1851 Calder, W., 19 Archibald Place
1886 Calder, William, 21 Commercial Street, Leith
1887 Callander, Henry, of Preston Hall, Dalkeith
1876 Campbell, Sir Archd. S. L., of Succoth, Bart., 23 Moray Place
1889 Campbell, Arthur, 4 Randolph Crescent
1889 Campbell, George, W.S., 51 Castle Street
1895 Campbell, John, Solicitor, 27 Dundas Street
1890 Campbell, P. W., W.S., 1 North Charlotte Street
1887 Campbell, W. G., 22 Lynedoch Place
1889 Carfrae, Geo., C.E., 1 Erskine Place
1869 Carphin, James R., C.A., 14 Hanover Street
1893 Charters, John (Drummond Brothers), 17 Greenside Place
1887 Chiene, Prof., 26 Charlotte Square
1862 Christie, C. J., 6 Glenorchy Terrace
1884 Christie, Wm., Braemar, Whitehouse Terrace
1855 Church, D. M., 27 Minto Street

Admitted
1883 Cleghorn, Thomas, Craigour, Liberton
1876 CLERK, Sir George Douglas, of Penicuik, Bart.
1894 Connell, Isaac, Secretary, Chamber of Agriculture, 52 Hanover Street
1884 Cook, Charles, W.S., 61 Castle Street
1882 Cook, Henry, W.S., 61 Castle Street
1892 Cook, James, Arniston, Gorebridge
1885 Cook, Wm. Home, C.A., 42 Castle Street
1865 Cousin, George, 140 Princes Street
1860 Cowan, C. W., of Logan House, Penicuik
1872 Cowan, George, Valleyfield, Penicuik
1874 Cowan, James, 35 Royal Terrace
1858 COWAN, Sir John, of Beeslack, Milton Bridge
1879 Cowan, John, W.S., 12 Hill Street
1879 Cowan, John, 13 South St Andrew St.
1893 Cox, Chas. T., W.S., 9 Buckingham Ter.
1892 Cox, Robert, of Gorgie, 34 Drumsheugh Gardens
1877 Crabbie, John M., 33 Chester Street
1863†CRAIG, Sir J. H. Gibson, of Riccarton, Bart., Currie
1877 Craig, Dr William, 71 Bruntsfield Place
1894 Crichton, David, 47 George Street
1849 Crichton, Hew Hamilton, W.S., 13 Nelson Street
1894 Crichton, Wm., Parduvine, Gorebridge
1875 Croall, Robt., Craigcrook Castle, Blackhall
1883 Cross, Adam P., Bowling Green Street, Leith
1880 Cross, Alexander, 13 Drummond Place
1870 Cunningham, C., V.S., Slateford
1888 Cunningham, Geo. M., C.E., 135 George Street
1894 Cunningham, Lawrence, Thornbank, Juniper Green
1883 Cunningham, St Clair, Bowling Green Street, Leith
1877 CUNYNGHAM, Sir R. K. A. Dick, of Prestonfield, Bart.
1867 Curror, David, 25 Northumberland St.
1873 Curror, P. R., Myreside, Edinburgh
1893 Cuthbert, Thomas Wilkinson, Dalmeny Park
1875 Dalgleish, Geo., Rosebery Mains, Gorebridge
1858 Dalgleish, L., 1 Rutland Square
1882 Dallas, D. F., S.S.C., 27 Charlotte Square
1862 DALRYMPLE, Sir Charles, of New Hailes, Bart., M.P., Musselburgh
1873 Dalziel, George, W.S., 66 Queen Street
1888 Dalziel, William, Muirhousedyke, West Calder
1877 Davidson, James I., Saughton Mains, Gorgie
1850 Davidson, W. J., 32 Drumsheugh Gardens
1888 Davidson, W. S., 54 Castle Street
1877 Dewar, James Cumming, of Vogrie, Ford
1883 Dewar, John R. W., V.S., Dick Veterinary College, 8 Clyde Street
1893 Dick, Thomas, Wester Causewayend, Kirknewton
1884 Dickson, James, Damhead, Loanhead
1879 Dickson, T. G., 3 North St David Street
1878 Dickson, W. T., W.S., 11 Hill Street
1866 Dobbie, John, Campend, Dalkeith
1889 Dods, Archibald, Halfhawkiln, Gorebridge
1884 Douglas, James, Cousland, Dalkeith
1894 Douglas, James Henry, Whitehill, Rosewell
1858 Dowell, Alex., 13 Palmerston Place
1869 Downie, Hay, Corstorphine
1894 DRUMMOND, Sir James H. Williams, of Hawthornden, Bart., Lasswade
1880 Dun, Finlay, 130 George Street
1884 Duncan, Peter, Eskbank, Dalkeith

Admitted
1848 Duncan, William, S.S.C., 13 Abercromby Place
1876 Duncan, William, S.S.C., 18 York Place
1887 Dundas, David, Advocate, 7 St Colme Street
1893 Dundas, Capt. Robert, yr. of Arniston, Gorebridge
1878 Dundas, Ralph, W.S., 16 St Andrew Sq.
1847 Dundas, Robert, of Arniston, Gorebridge
1880 Dundas, William J., C.S., 16 St Andrew Square
1872 Dunlop, George, W.S., 20 Castle Street
1877 Dunn, Malcolm, The Gardens, Dalkeith
1858 Durie, David, 1 Queensferry Gardens, Edinburgh
1878 Dykes, James, Cuicken, Penicuik
1874 Edgar, John, Kirkettle, Roslin
1877 Elder, James, Rodinglaw, Currie
1892 Elder, Samuel, Whitehill Mains, Musselburgh
1876 Ferguson, Archd. A., 196 High Street, Portobello
1868 Ferguson, John, Burghlee, Loanhead
1869 Finlay, John H., W.S., Register House
1890 Fisher, Thomas, Whitehill, Rosewell
1864 Fleming, James Nicol, 12 George Square
1882 Fleming, Jas. S., 16 Grosvenor Crescent
1893 Fleming, John, Coates, Penicuik
1875 Fletcher, John D., 6 Barnton Terrace, Blackhall
1878 Ford, G., Saughton Hall Mains, Murrayfield
1893 Ford, Jas., Saughton Hall Mains, Gorgie
1871 Forgan, Andrew, 10 Claremont Terrace
1882 Forrester, John, 39 Broughton Place
1877 Foulis, David, 61 George Street
1869 FOULIS, Sir Jas. Liston, Bart., Millburn Tower, Corstorphine
1868 Fraser, Alex., Canonmills Lodge
1894 Gardner, Adam, Melville Grange, Liberton
1855 Gardner, R., 12 Claremont Terrace
1877 Gardner, William, East Langton, Mid-Calder
1893 Gardner, William G., Carrington Barns, Gorebridge
1886 Garson, Wm., W.S., 5 Albyn Place
1887 Geddes, G. H., 21 Young Street
1892 Gibson, A. H., 5 Crawford Road—*Free Life Member*
1893 Gibson, George, Brunstane Mills, Musselburgh
1886 Gibson, Rev. John, 22 Regent Terrace
1847 GILLESPIE, Sir John, W.S., 53 Northumberland Street
1890 Gilmour, R. Wolridge Gordon, of Craigmillar
1869 Glendinning, G. R., Hatton Mains, Kirknewton
1874 Glendinning, J. P., Overshiels, Mid-Calder
1865 Goldie, R. G. M., 3 Comely Green Place
1883 Gow, Andrew, 12 Castle Street
1893 Graham, David, Leyden, Kirknewton
1887 Graham, William, 9 Hill Street
1861 Gray, James, Braehead Mains, Cramond Bridge
1884 Gray, James, Harperigg, Kirknewton
1878 Gray, Robert Smith, Southfield, Duddingston
1877 Greig, R. M., Fountainbridge
1889 Grey, John Edward, 20 Lauriston Place
1869 Grieve, John, Balmoral Hotel, Princes Street
1893 Guild, Alexander, Greenhead, Pencaitland (2 Thistle Court)
1877 Gulland, W. J., Monkton Hall, Musselburgh
1869 Hagart, J. V., W.S., 140 Princes Street
1864 Halkett, Lieut.-Col. J. C., of Cramond

Admitted
1873 Hamilton, Robert, 18 Waterloo Place
1861 Hamilton, Wm., of Cairns, Kirknewton
1843 Handyside, W., 21 Magdala Crescent
1884 Harper, James, Fordel, Dalkeith
1871 Harper, William, Sheriffhall Mains, Dalkeith
1893 Harwell, John Hood, Whitemoss, Kirknewton
1875 Hay, Alex., 41 Constitution St., Leith
1862 Hay, James, 9 Castle Street
1893 Hay, Robert, Councillor, Huntly Street, Canonmills
1893 Henderson, Allan Macfarlane, 39 Palmerston Place
1863 Henderson, Jas., Walton, Corstorphine
1876 Henderson, John, C.A., 40 Leamington Terrace
1863 Higgins, Robert, 4 Garscube Terrace, Murrayfield
1863 Hogg, Henry, Symington Mains, Stow
1876 Hogg, Robert, 18 Ann Street
1859 Hogg, Robert, Rosemay, Leadburn
1880 Hogg, Thos., Oxenford Mains, Dalkeith
1858 Hood, Archibald, Rosewell
1878 Hope, Alex., Kingston Grange, Liberton
1848 Hope, Jas., of Belmont, Murrayfield
1877 Hope, James Edward, New Club
1861 Howe, Alex., W.S., 32 Charlotte Square
1887 Howie, Archibald, Rosebery, Gorebridge
1877 Hunter, J., jun., Woodhall Mains, Juniper Green
1894 Hunter, John, 20 Chambers Street, Edinburgh
1875 Hunter, John, Nethershiel, East Calder
1853 Hunter, Wm. B., Aracan Cottage, Musselburgh
1872 Hutchison, J. T., 12 Douglas Crescent
1875 Hutchison, Thos., Broomhills, Loanhead
1877 Inch, Robert, 1 Victoria Street
1869 Inglis, A. W., 30 Abercromby Place
1884 Inglis, H. H., W.S., 8 North St David St.
1887 Innes, John C., W.S., 32 Queen Street
1872 Jack, Gavin, Swanston, Lothianburn
1860 Jack, Samuel, Crichton Mains, Dalkeith
1869 Jack, Thomas, Hermiston, Currie
1885 Jameson, Andrew, 14 Moray Place
1860 Jamieson, G. A., C.A., 21 St Andrew Sq.
1871 Jamieson, J. A., W.S., 66 Queen Street
1858 Jamieson, Wm. H., Thornlie Villa, Loanhead
1869 Jeffrey, David, 14 Randolph Crescent
1880 Jenkinson, A. D., 10 Princes Street
1872 Johnson, W. H., Tweed Villa, Relugas Road
1852 Johnston, Alex., Hailes, Slateford
1891 Johnston, Henry, Advocate, 33 Moray Pl.
1892 Jones, Charles Digby, 14 Lynedoch Place
1863 Kay, Wm., Broomieknowe, Lasswade
1893 Keith, Davidson, 65 George Street
1891 Kennaway, David, Polton Farm, Lasswade
1860 Kennaway, Robt., 10 Middleby Street
1888 Kerr, George, 9 Great Stuart Street
1884 Kerr, John, Yorkston, Gorebridge
1889 Kerr, Thomas, W.S., 16 Hill Street
1869 Kidd, Walter, Balleny, Balerno
1894 Kidd, William, Pinkie, Musselburgh
1872 King, James, West Mills, Colinton
1871 King, J. F., Chambers Street
1876 Kinnear, C. G. H., 12 Grosvenor Cres.
1877 Laing, Alex., S.S.C., 59 Manor Place
1893 Laird, Robert, 17 Frederick Street
1884 Lamond, Robert, Malcolmstone, Currie
1895 Lamont, John, 9 Howe Street
1878 Landale, James, 1 Summerfield, Leith
1877 Laurence, P., 50 Frederick Street
1872 Lawrie, John W., Stow
1872 Lawrie, Thos., Esperston, Gorebridge
1878 Lee, A. H., 58 Manor Place
1868 Lee, John, 16 St Albans Road

Admitted
1878 Lindsay, Hugh, 13 Gladstone Place, Leith
1884 Lindsay, Robert, Windsor House, Ferry Road
1889 Lindsay, W. P., W.S., 16 Queen Street
1866 Lockhart, R., jun., 10 Polwarth Terrace
1884 Logan, C. B., W.S., 23 Queen Street
1872 Loney, Peter, 22 George Square—*Free Life Member*, 1892
1874 Lothian, M. J., Redwood, Spylaw Road
1891 Lowe, W. D., W.S., 66 Queen Street
1889 Lowson, James G. F., Polton, Mid-Lothian
1850 Lyall, Robt., 16 Bellevue Crescent
1859 Macadam, Dr S., Surgeons' Hall
1884 Macadam, Prof. W. Ivison, Surgeons' Hall
1874 McCallum, A. I., 19 Grassmarket
1864 M'Candlish, John M., 27 Drumsheugh Gardens
1869 M'Culloch, R. C., 15 Brougham Street
1883 Macdonald, James, 3 George IV. Bridge —*Secretary of the Society*
1886 Macdonald, R. B., Granton Mains, Edin.
1875 M'Dougal, Thos., Eskvale, Penicuik
1870 M'Dowall, Andrew, Hareclaw, Currie
1878 M'Dowall, T. N., Remote, Dalkeith
1862 Macfie, C., of Gogarburn, Corstorphine
1865 Macfie, D. J., of Borthwick Hall, Heriot
1893 Macfie, J. W., of Dreghorn, Colinton
1869 Macfie, Wm., of Clermiston, Corstorphine
1877 M'Gowan, Robert, 46 Fountainhall Road
1870 M'Gowan, William, 46 Fountainhall Rd.
1895 M'Harrie, Stair, Oxenford, Dalkeith
1884 Mackay, W. B., 17 Lennox Street
1869 Mackenzie, A. K., of Ravelrig, 19 Grosvenor Crescent
1879 Mackenzie, A. D., 6 Hartington Gardens
1884 Mackenzie, D. F., Morton Hall, Liberton
1848 Mackenzie, John, New Club
1879 Mackenzie, John, W.S., 16 Royal Circus
1848 Mackenzie, J. Ord, W.S., 9 Hill Street
1892 M'Kinnon, George, Melville Castle, Lasswade
1892 Maclagan, Philip R. D., 14 Belgrave Pl.
1858 MACLAGAN, Prof. Sir Douglas, 28 Heriot Row
1873 Maclagan, R. C., M.D., 5 Coates Crescent
1881 M'Laren, Alex., 11 Assembly St., Leith
1892 MacLennan, Wm., Prestondene, Ford, Dalkeith
1894 M'Leod, A. G., 4 Great King Street, Edinburgh
1893 Macmillan, John, Corstorphine Hill House
1883 Macpherson, C. E. W., C.A., 28 St Andrew Square
1882 Macpherson, Prof. N., 6 Buckingham Terrace
1877 Maitland, David, of Dundrennan, New Club
1877 Mark, Robert, Valleyfield Street
1880 Marshall, Rev. Theodore, 10 Coates Gardens
1874 Martin, J., 38 Lauriston Place
1886 Massie, W. H., 1 Waterloo Place
1875 Mather, Edward, The Lee, Edinburgh
1871 Matheson, Kenneth, 58 Morningside Drive
1860 Melrose, Patrick, Tower House, Tower Street, Portobello
1894 MELVILLE, Viscount, Melville Castle, Lasswade
1849 Melvin, Jas., 43 Drumsheugh Gardens
1893 Menzies, D., C.E., 39 York Place
1871 Menzies, Robert, S.S.C., 16 Duke Street
1870 Menzies, Wm. J., W.S., 123 George Street
1870 Merricks, H. J., Hay Mains, Harburn, West Calder
1884 Methven, John, 6 Bellevue Crescent

Admitted
1892 Mettam, A. E., Veterinary College, 8 Clyde Street
1882 Mill, George, 21 St Andrew Square
1883 Milne, Alex., 32 Hanover Street
1887 Mitchell, David, Lauriston, Davidson's Mains
1869 Mitchell, Wm., S.S.C., 11 South Charlotte Street
1892 Moffat, James, 48 Castle Street
1876 Moir, Peter, 74 Nicolson Street
1848 MONCREIFF, Lord, 15 Great Stuart Street
1885 MONCREIFF, Hon. Jas. W., 6 Ainslie Pl.
1866 Moncrieff, D. S., W.S., 24 George Square
1884 Morton, Thomas, Redheugh, Gorebridge
1886 MORTON, The Earl of, Dalmahoy, Wilkieston
1887 Mungle, John T., West Calder
1891 Munro, Duncan, 8 Dalrymple Place—*Free Life Member*
1886 Munro, John C., yr. of Marchbank, Balerno
1880 Munro, William, of Marchbank, Balerno
1875 Murdoch, Geo. Burn, 31 Morningside Road—*Free Life Member*
1870 Mure, William J., New Club, Princes Street
1880 Murray, Lieut.-Col., C. S., 143 Warrender Park Road
1877 Murray, A. G., 7 Rothesay Terrace
1875 Murray, R. W. E., Blackford House, Blackford Avenue—*Free Life Member*
1857 Murray, Thomas, Braidwood, Penicuik
1890 Murray, T. M., W.S., 12 Lennox Street
1885 Murray, Wm. Hugh, W.S., 48 Castle St.
1890 Mylne, James, W.S., 36 Castle Street
1888 Naismith, R. T., 2 Ethel Terrace, Plewlands
1890 Nisbet, Chris. C., of Stobshiel, W.S., 23 York Place
1893 Nisbet, Robert, Kingsknowes, Slateford
1847 Nisbett, J. M., of Cairnhill, Drum, Edinburgh
1860 Niven, A. T., C.A., 16 Young Street
1862 Norie, H. H., Union Bank, Edinburgh
1883 Oliver, James, 1 London Street
1876 Ovens, William R., Leith
1874 Park, Ebenezer, Greenside Lane
1873 Park, J. D., Greenside Lane
1874 Park, William, Brunstane, Portobello
1889 Pate, Thomas, Windydoors, Stow
1864 Paterson, D. A., Merchant, Leith
1878 Paterson, James, of Bankton, Mid-Calder
1877 Paterson, John, Meadowspott, Dalkeith
1876 Paterson, J. T. S., 55 Grange Loan
1894 Paterson, John W., 14 Brunstane Road, Joppa—*Free Life Member*
1877 Paterson, Richard L., Meadowspott, Dalkeith
1860 Paterson, Thos., W.S., 81A George Street
1890 Patten, Hugh, W.S., 42 Castle Street
1880 Paul, George M., C.S., 16 St Andrew Sq.
1884 Pearson, A. G., of Luce, 10 Queensferry Street
1878 Pendreigh, George, Catcune, Gorebridge
1894 Penman, William, Assoc. M.I.C.E., Craigview, Marchhall Road, Edinburgh
1893 Pitman, A. R. C., W.S., 48 Castle Street
1859 Pitman, Frederick, W.S., 11 Great Stuart Street
1859 Plenderleith, Arch., Blackhope, Heriot
1894 Poole, Wm., Corn Exchange Buildings
1880 Pott, George, of Potburn, 55 Albany St.
1865 Prentice, R. R., 6 Mayfield Terrace
1863 Pringle, D., Torquhan, Stow
1876 Pringle, J., 5 Tipperlinn Road
1877 Pringle, Wm., Huntly Cot., Gorebridge
1889 Raeburn, Norman, 49 Manor Place—*Free Life Member*
1881 Ramsay, R. G. Wardlaw, of Whitehill, Rosewell

Admitted
1890 Ramsay, William, of Bowland, Stow
1874 Rankine, Prof. John, 23 Ainslie Place
1887 Readman, J. B., 4 Lindsay Place
1893 Reid, James, W.S., Drem, East Lothian (2 Thistle Court)
1888 Renwick, Andrew, East Pilton, Edinburgh
1879 Renwick, Wm., Meadowfield, Corstorphine
1885 Rew, William, 4 Bernard Street, Leith
1884 Richard, John Millar, 20 Grosvenor Crescent
1877 Riddell, A., 5 Grassmarket
1869 Ritchie, Charles, S.S.C., 20 Hill Street
1877 Ritchie, D., 13 Windsor Street
1865 Ritchie, W., of Middleton, Gorebridge
1853 Ritchie, W., Woolmet, Dalkeith
1884 Robertson, J. A., C.A., 33 Charlotte Sq.
1876 Robertson, Lieut.-Col. James C., United Service Club
1889 ROBERTSON, Rt. Hon. J. P. B., Lord Justice-General, 19 Drumsheugh Gardens
1873 Rodgie, Henry, St Clement's Wells, Musselburgh, N.B.
1893 Ross, Alexander, Edinburgh Live Stock Mart, Edinburgh
1886 Russell, A., 1 Mansion House Road
1893 RUSSELL, Sir James Alex., Woodville, Canaan Lane
1851 Russell, James M., 11 Pitt Street, Portobello
1860 Rutherford, G., Montcath's Houses, Gorebridge
1887 Rutherford, Richard, V.S., Bread Street
1880 St Clair, J. S., Musselburgh
1864 Sanderson, Wm., Mount Lothian, Eskbank
1892 Sanford, Major Charles Henry, Becslack, Milton Bridge
1854 Scoon, K., 46 Rankeillor Street
1875 Scott, Alex., 3 Bellfield, Portobello
1876 Scott, A. T. S., 1 Hill Street
1891 Scott, Rev. Arch., D.D., 16 Rothesay Place—*Chaplain to the Society*
1880 Scott, E. E., C.A., 64 Queen Street
1848 Seton, Geo., Conservative Club, Princes Street
1889 Shiells, James, Muirhouse, Stow
1884 Shillinglaw, William, 65 Lochend Road, Leith
1860 Simpson, Alex., Wallyford, Musselburgh
1887 Simpson, James, Ingliston, Ratho
1878 Simpson, Thomas, Duddingston, Portobello
1874 Simson, C. S., 47 Queen Street
1869 Skinner, W., of Corra, W.S., 35 George Square
1846 Skirving, R. Scot, 29 Drummond Place
1886 Skirving, Thos. M., Niddrie Mains, Liberton
1889 Slimon, Robert, of Whitburgh, Ford, Dalkeith
1877 Smail, James, Commercial Bank, Edinburgh
1884 Smart, Alex., Bow, Stow
1864 Smart, Jas., Liberton Park, Liberton
1880 Smart, J. C., 54 George Square
1893 Smith-Sligo, Archibald D. (of Inzievar and Carmyle), 5 Drummond Place
1881 Smith, A. D., C.A., 29 St Andrew Sq.
1872 Smith, Dr G. P., care of P. Ronaldson, C.A., 3A North St David Street
1895 Smith, Harry Wedderburn, W.S., 9 Kilgraston Road
1878 Smith, J., 89 Grassmarket
1867 Smith, J. Turnbull, C.A., 5 Belgrave Place
1884 Smith, Thomas H., National Bank, Edinburgh

Admitted
1884 Smith, William, 1 Grassmarket
1893 Somner, George (Peter Lawson & Son, Limited), 1 George IV. Bridge
1854 Starforth, John, Architect, 37 York Pl.
1893 Stark, James, 26 Earl Grey Street
1870 Steel, Lieut.-Col. G. Mure, 33 Northumberland Street
1861 Stenhouse, Jas., Turnhouse, Cramond Bridge
1864 Steuart, James, Dalkeith Park, Dalkeith
1884 Steuart, J. H., Selms, Kirknewton
1893 Steuart, Thomas Elis, Stellknowe, Leadburn, and 48 Palmerston Place
1855 Stevenson, Andrew, 18 Royal Circus
1886 Stevenson, David Alan, C.E., 84 George Street
1893 Stewart, James Robert Hunter, 4 Albyn Place
1894 Stewart, William, Dalhousie Castle, Bonnyrigg
1893 Stockman, Stewart, M.R.C.V.S., 8 Clyde Street
1878 Stodart, J. A., Broomvale, Broomieknowe, Lasswade
1851 Stodart, John, Calderwood Bank, Lasswade
1890 Stoddart, James Edward, of Howden, Mid-Calder
1878 Strathern, Robt., W.S., 12 South Charlotte Street
1853 Sutherland, Eric, Enfield, Lasswade
1865 Sutherland, Jas. B., S.S.C., 10 Windsor Street
1858 Swan, James, 47 Lauriston Place
1858 Swan, Thomas, 47 Lauriston Place
1889 Sydserff, John Buchan (Ruchlaw), National Bank, 142 Princes Street
1874 Syme, David, 1 George IV. Bridge
1876 Symington, Jas., 55 Fountainhall Road
1893 Taylor, J. Pringle, Dunsmure, Corstorphine
1893 Taylor, Jas. (Easter Drylaw), Bangholm House, Ferry Road, Edinburgh
1884 Taylor, Peter, Lochend
1893 Taylor, S. P. (Peter Lawson & Son, Limited), 1 George IV. Bridge
1872 Taylor, Thos., Seed Merchant, Dalkeith
1893 Tennent, David B. Clark, Cammo, Cramond Bridge
1879 Thiem, Albert M., Windsor Hotel, Princes Street
1884 Thin, John, Ferniehirst, Stow
1874 Thoms, George Hunter, 13 Charlotte Square
1867 Thomson, Charles W., C.A., 16 Lennox Street
1889 Thomson, George Munro, W.S., 123 George Street
1858 Thomson, James, 53 George Street
1895 Thomson, James, yr. of Glenpark, Balerno
1867 Thomson, John Comrie, 30 Moray Place
1870 Thomson, Lockhart, S.S.C., 114 George Street
1873 Thomson, Mitchell, 9 South St Andrew Street
1850 Thomson, Peter, Conservative Club, Princes Street
1888 Thomson, Robert, Rusha, West Calder
1893 Thomson, Robert Harvey, 26 Royal Ter.
1884 Thorburn, David, Brockhouse, Stow
1872 Thyne, John, 5 Dean Terrace
1893 Thyne, Kennard, Pentland Mains, Loanhead
1860 Tod, James C., Currie
1870 Tod, John W., W.S., 66 Queen Street
1876 Todd, David, 2 Dick Place
1865 Todd, Jas., 2 Morningside Gardens
1893 Torphichen, Lord, Calder House, Mid-Calder
1871 Torrance, Archibald P., Kipplelaw, Dalkeith
1877 Torrance, T. A., Camps, Wilkieston
1894 Torrance, T. A., Kipplelaw, Dalkeith
1876 Traill, Thomas, Inverleith Terrace
1846 Traquair, Ramsay H., Colinton
1894 Tress, Wm. Maxwell (Jenner & Co.), Princes Street
1865 Trotter, Coutts, 17 Charlotte Square
1865 Trotter, Lieut.-Col. H., of Morton Hall, Liberton
1878 Tuke, Dr J. B., Saughton Hall
1874 Turnbull, David, W.S., 5 South Charlotte Street
1868 Turner, Prof. Sir W., M.B., 6 Eton Terrace
1893 Tytler, James Wm. Fraser-, Woodhouselee, Mid-Lothian
1893 Usher, Frederick, Norton Mains, Ratho
1885 Usher, John, of Norton, Ratho
1864 Veitch, Chris., 11 Rothesay Place
1874 Waddell, A. Peddie, 6 Albyn Place
1888 Waddell, George, 4 St Andrew Square
1857 Wakelin, John, Oil Mills, Musselburgh
1877 Walcot, John, 13 Greenside Place
1870 Walker, Alexander, Stagebank, Heriot
1872 Walker, Alex. J., 5 Manor Place
1860 Walker, James, of Dalry, Hanley, Corstorphine
1882 Walker, R. H., of Hartwood, West Calder
1884 Walker, James, Limefield House, West Calder
1835 Walker, Sir W. S., K.C.B., 5 Manor Place
1893 Wallace, John William, of Shoestanes (8 Bernard Street, Leith)
1878 Wallace, Prof. Robert, University, Edinburgh—*Free Life Member*
1882 Wallace R. Hedger, c/o Taylor, 4 Panmure Place
1858 Warrender, Sir G., of Lochend, Bart., Bruntsfield House
1837 Waterston, Charles, 39 Albany Street
1869 Watherston, James, 29 Queensferry St.
1869 Watherston, Wm., 17 Rothesay Place
1882 Watson, G. G., W.S., 32 Albany Street
1878 Watson, Jas. Graham, 22 Learmonth Ter.
1864 Watson, John, Kingsbeck, Cluny Drive
1884 Wauchope, Lieut.-Colonel A. S., of Niddrie Marischall, Liberton
1882 Wauchope, Sir J. D. D., of Edmonstone, Bart., 12 Ainslie Place
1863 Webster, J., 12 Brunstane Road, Portobello
1884 Weir, W. C., Middleton, Gorebridge
1886 Welsh, W. M., 1 Waterloo Place
1877 Welwood, J. A. Maconochie, Meadowbank House, Kirknewton
1884 Wenley, James A., Bank of Scotland
1876 White, James, Stagehall, Stow
1872 White, Robert, Musselburgh
1893 Whitson, George, 147 Gilmore Place
1884 Wight, Robert, Suffolk House, Suffolk Road
1884 Wilkie, Captain W., of Ormiston, Kirknewton
1873 Will, Robert W., S.S.C., 37 Queen Street
1867 Williams, W., Principal, New Veterinary College, Leith Walk
1881 Williams, W. O., New Veterinary College, Leith Walk
1870 Wilson, P., care of Miss Logan, 1 Catherine Place, Warriston Road
1858 Wilson, Richard, C.A., 28 Great King St.
1894 Wood, John Phillip, W.S., Professor of Conveyancing, University of Edinburgh
1875 Wylie, Alexander, W.S., 54 Queen St.
1890 Wylie, James, Royal Bank, 1 Leven St., Edinburgh

Admitted
1854 Young, Hon. Lord, 28 Moray Place
1888 Young, David, of the *North British Agriculturist*, 377 High Street
1893 Young, James (James Young & Sons), Bryson Road
1876 Young, John, St Margarets, Wester Duddingston
1880 Young, J. W., W.S., 22 Royal Circus
1887 Younger, George, 4 Douglas Gardens
1870 Younger, Henry J., Abbey Brewery
1863 Younger, Robert, 15 Carlton Terrace
1894 Younger, William, 29 Moray Place

## HADDINGTON.

1882 Ainslie, John, jun., Morham Mains, Haddington
1893 Amos, John, Alderston, Haddington
1877 Anderson, Col., of Bourhouse, Dunbar
1850 Anderson, G. B., Meikle Pinkerton, Dunbar
1878 Anderson, W. W., of Kingston, North Berwick
1881 Andrew, H., Lennoxlove Acredales, Haddington
1892 Baillie, Wm., Nurseries, Haddington—*Free Life Member*
1860 Baird, Sir David, of Newbyth, Bart., Prestonkirk
1863 Balfour, Right Hon. A. J., of Whittinghame, M.P., Prestonkirk
1893 Bannatyne, William, V.S., Haddington
1888 Bayley, Isaac F., Halls, Dunbar
1893 Bertram, Andrew, Townhead, Gifford
1859 Binnie, John, Birnieknowes, Cockburnspath
1893 Binnie, Robert J., Seton Mains, Longniddry
1892 Blair, Thomas, Hoprig Mains, Macmerry
1872 Brand, James, Dunbar
1880 Bridges, Andrew, Engineer, North Berwick
1868 Broadwood, T., Crowhill, Dunbar
1884 Calder, Robt., Cairndinnies, Haddington
1859 Clapperton, James, Garvald Mains, Prestonkirk
1864 Clark, James, Kirklandhill, Dunbar
1893 Clark, John, Wamphray, North Berwick
1880 Clark, Thomas, Oldhamstocks Mains, Cockburnspath
1889 Connor, G. A., Craigielaw, Longniddry
1886 Courtney, Wm., Portobello Farm, Tranent
1893 Cree, W., of Gifford Bank, Gifford
1891 Crosbie, Alexander, Blegbie, Humbie
1883 Darling, James, Priestlaw, Duns
1887 Deans, John, East Fenton, Drem
1872 Dewar, David, Murrays, Ormiston
1895 Dobbie, Æmilius S., East Fenton, Drem
1877 Dodds, Samuel, Sommerfield, Haddington
1877 Donald, Andrew, Longnewton, Gifford, Haddington
1884 Elcho, Lord, M.P., Gosford, Longniddry
1881 Elder, Hugh, East Bearford, Haddington
1890 Elder, James, Haddington
1890 Elder, Thomas, Stevenson Mains, Haddington
1884 Elliot, Walter, Pitcox, Dunbar
1875 Ewart, H., Tyninghame, Prestonkirk
1875 Fernie, James A., Smeaton, Dalkeith
1857 Fletcher, J., of Salton, Pencaitland
1849 Ford, Wm., Fenton Barns, Drem
1877 Fyshe, Peter, Newtonlees, Dunbar
1859 Gaukroger, G., Southfield, Longniddry
1888 Gemmell, Wm., Greendykes, Macmerry
1889 Gillespie, William, Athelstaneford, Drem
1855 Gray, Wm., Brownrigg, North Berwick

Admitted
1882 Gray, W. W., of Nunraw, Prestonkirk
1876 Greenshields, T. A., Windymains, Salton
1893 Gregor, Charles E., Innerwick, East Lothian
1857†Haddington, The Earl of, Tyninghame, Prestonkirk
1859 Haldane, Robt., Phantassie, Prestonkirk
1878 Hall, Sir Basil F., of Dunglass, Bart., Cockburnspath
1872 Handyside, J. B., Fenton, Drem
1862 Hay, Captain J. G. Baird, of Belton, Dunbar
1885 Henderson, George, Upper Keith
1893 Hepburn, Sir Archibald Buchan, of Smeaton, Bart., Prestonkirk
1886 Hope, Harry, Oxwell Mains, Dunbar
1865 Hope, Henry W., of Luffness, Drem
1847 Hope, James, East Barns, Dunbar
1878 Hope, William James, East Barns, Dunbar
1893 Horn, Wm., of Woodcote Park, Blackshiels
1877 Houston, M. H., of Beechhill, Haddington
1893 Hume, A., V.S., Haddington
1887 Hunter, Richard, of Thurston, Dunbar
1893 Hunter, William, Woodside, Gladsmuir
1877 Johnston, Alex., North Mains, Ormiston
1893 Kerr, William Walker, Ferrygate, Drem
1873 King, William, jun., Wolfstar, Ormiston
1859 Kinloch, Sir Alexander, of Gilmerton, Bart., Drem
1885 Kinloch, David A., yr. of Gilmerton, Guards' Club, London
1893 Knox, Robert, Carlaverock, Tranent
1878 Lawrie, Jas. D., of Monkrigg, Haddington
1893 Lee, Joseph, Markle, Prestonkirk
1870 M'Culloch, D., Bank Agent, North Berwick
1864 M'Ewen, J., Redside Farm, North Berwick
1877 Mark, John, Sunnyside, Prestonkirk
1871 Nelson, Charles, Skateraw, Innerwick
1889 Ogilvy, H. T. N. Hamilton, Biel, Prestonkirk
1893 Park, John, Hoprig, Macmerry
1866 Park, Thos. B., Springfield, Haddington
1889 Park, Wm. B., of Blegbie, Upper Keith
1865 Punton, F. H., Aberlady Mains, Longniddry
1894 Reid, James, Twynholm, Pencaitland
1863 Richardson, J., Hilton Cottage, Haddington
1862 Riddell, Wm., Cocklaw, Oldhamstocks, East Lothian
1893 Ritchie, J. B., Samuelston, Haddington
1873 Robertson, James F., Newhouse, Drem
1894 Robertson, John, Beanston Mains, Haddington
1872 Robertson, Robt., West Barns, Dunbar
1874 Robson, John, Millknowe Granshaws, Duns (Newton, Bellingham)
1886 Scott, Alex., Summerfield, Dunbar
1883 Scott, G. R., Commercial Bank, Dunbar
1878 Sharp, John J., Ewingston, Gifford—*Free Life Member*
1877 Shields, James, Dolphington, Tranent
1850 Shirriff, Samuel D., 3 Tantallon Terrace, North Berwick
1868 Smith, Andrew, Longniddry
1853 Smith, Chas., Whittinghame, Prestonkirk
1876 Smith, D. W. E., North Elphinstone, Tranent
1882 Smith, E. Hedley, Whittinghame, Prestonkirk—*Free Life Member*
1894 Steven, John, Begbie, Haddington
1893 Stewart, John, Nisbet, Pencaitland
1855 Stodart, William, Wintonhill, Tranent

Admitted
1863 Stuart, A. C., of Eaglescairnie, Haddington
1862 Swinton, P. Burn, Holyn Bank, Gifford
1853 Sydserff, T. Buchan, of Ruchlaw, Prestonkirk
1855 Taylor, J. B., Seton West Mains, Prestonpans
1859 Turnbull, P., Little Pinkerton, Dunbar
1877 Turnbull, Walter, Tynemount, Ormiston
1879 TWEEDDALE, The Marquis of, Yester, Haddington
1859 Tweedie, Alexander, Coats, Haddington
1881 Wallace, John, Hailes, Haddington
1888 Watt, Miss Adelaide, of Spott, Dunbar
1868 Watt, James, New Mains, Dunbar
1850 Welsh, Alexander, Waughton, Prestonkirk
1847†WEMYSS and MARCH, The Earl of, Gosford, Longniddry
1888 Wilson, Peter, Rhodes, North Berwick
1885 Wylie, N. M., New Club, North Berwick
1893 Wylie, Robert, Haugh, North Berwick
1884 Wyllie, Alex., Thurston Mains, Dunbar
1895 Wyllie, David, Longnewton, Haddington
1877 Young, D. S., Bonnington, North Berwick
1867 Young, James B., Elphinstone Tower, Tranent
1860 Yule, Edward, Balgone, North Berwick

## LINLITHGOW.

1874 Allan, J., Corn Merchant, Bo'ness
1875 Allan, James, jun., Bo'ness
1855 Bartholomew, J., Craigton House, Winchburgh
1883 Bartholomew, John, Duntarvie, Winchburgh
1858 Borthwick, John, V.S., Kirkliston
1876 Brock, J. E., Overton, Kirkliston
1885 Brownlee, George, Cousland, Bathgate
1875 Brownlee, James, East Whitburn Farm
1865 Bryce, James, East Whitburn, Whitburn
1860 Cadzow, J., Bangour, Uphall
1873 Chapman, James, Balencrieff Mill, Bathgate
1894 Clarkson, Robt., of Toravon, Linlithgow
1860 Davidson, George, Carriden, Bo'ness
1881 Drysdale, And. L., The Leuchold, Dalmeny Park, Edinburgh
1870 Dudgeon, Alex., Humbie, Kirkliston
1869 Dudgeon, George, Almondhill, Kirkliston
1887 Dudgeon, Jn. G., Easter Dalmeny, Dalmeny
1891 Ferguson, John, Sheriff-Clerk of Linlithgow
1889 Ferrier, Willam C., Birkenshaw, Bathgate
1868 Fleming, George, Haugh, Kirkliston
1869 Glendinning, Alex., New Mains, Kirkliston
1876 Graham, William, Wheatlands, Cramond Bridge
1850 Hill, John, Carlowrie, Cramond Bridge
1860 Hog, Thos. A., of Newliston, Kirkliston
1887 Hope, Capt. Thos., of Bridge Castle, M.P., Bathgate
1884†HOPETOUN, The Earl of, Hopetoun House, South Queensferry
1892 Hutchison, Thomas, of Carlowrie, Kirkliston
1856 Johnston, John, Banker, Bathgate
1880 Learmonth, G. Gray, North Bank, Bo'ness
1863 Lesslie, James, Boghall, Linlithgow
1889 Macaulay, Jas. F., Kinneil Estate Office, Bo'ness
1869 M'Kinlay, John, Hardhill, Bathgate
1847 M'Lagan, Peter, of Pumpherston, Mid-Calder
1883 MacNab, John, Glenmavis, Bathgate
1879 Masson, Rev. Alex., The Manse, Kirkliston
1867 Meikle, John, Grougfoot, Linlithgow
1879 Meikle, William, East Bonhard, Linlithgow
1886 Melville, G. F., Sheriff-Substitute, Linlithgow
1877 Mitchell, George, Broxburn Park, Broxburn
1859 Morrison, J., West Dalmeny, Dalmeny
1891 Murray, John, Bridgehouse, Westfield—*Free Life Member*
1888 Nimmo, Thos., Kirklands, Winchburgh
1873 Orr, James, Hill, Whitburn
1893 Paul, James, Walton, Linlithgow
1894 Robertson, John, Ochiltree Place, Linlithgow
1868†ROSEBERY, The Earl of, K.G., Dalmeny Park, Edinburgh
1889 Rough, Robert L. (R. Rough & Sons), Broxburn
1882 Russel, James, Dundas Castle, Queensferry
1887 Shields, John, Newlands, Falkirk
1864 Steuart, Captain R., of Westwood, West Calder
1881 Stewart, G. M. F., of Binny, Linlithgow
1888 Tod, Wm., Pardovan, Philipstoun, Linlithgowshire
1893 Veitch, W. H., Dalmeny Park, Edinburgh
1880 Walker, Thos. Geo., Kilpunt, Broxburn

# 5.—ABERDEEN DISTRICT.

EMBRACING THE

COUNTIES OF ABERDEEN, BANFF, FORFAR (EASTERN DIVISION), AND KINCARDINE.

## ABERDEEN.

Admitted
1872 HER MOST GRACIOUS MAJESTY THE QUEEN
1873*HIS ROYAL HIGHNESS THE PRINCE OF WALES

1868†ABERDEEN, The Earl of, Haddo House, Methlick
1885 Abernethy, David W., Ferryhill Foundry, Aberdeen
1884 Adam, Alexander, 38 Gilcomston Park, Aberdeen
1890 Adam, Walter, Corskellie, Huntly
1876 Ainslie, Ainslie Douglas, of Delgaty Castle, Turriff
1875 Ainslie, Wm., Pitfour, Mintlaw
1894 Aitchison, Walter, Coniecleuch, Huntly
1876 Alexander, George, South Balnoon, Huntly
1894 Allan, David, Union Street, Aberdeen
1889 Allan, John, Aikenshill, Culter Cullen, Aberdeen
1894 Anderson, Geo., Nether Aucharnie, Forgue, Huntly
1893 Anderson, George, Sandford Lodge, Peterhead
1885 Anderson, George, West Fingask, Old Meldrum
1868 Anderson, John, Mill of Wester Coull, Tarland
1876 Anderson, John M., Huntly
1881 Anderson, Robert, Wester Coull, Tarland
1893 Anderson, William, Bon Accord Works, Aberdeen
1894 Anderson, Wm., Saphock, Old Meldrum
1876 Anderson, Wm., Pitaboutie, Coull, Tarland
1876 Anderson, William, Wardes, Kintore
1885 Angus, Samuel, Bonnymuir, Aberdeen
1882 Argo, James, Cairdseat, Udny, Aberdeen
1894 Arnott, Geo., Leather Merchant, Huntly
1885 Bain, George, Old Mill Reformatory, Aberdeen
1893 Ballingall, Robert Rennie, Crimmonmogate, Lonmay
1858 Barclay, C. A., Aberdour House, Fraserburgh
1862 Barclay, J. W., 60 Dee Street, Aberdeen
1885 Barclay, Morrison, 60 Dee Street, Aberdeen
1893 Baron, James, C.E., 7 Union Terrace, Aberdeen
1884 Barron, Geo. F., Meikle Endovie, Alford, N.B.
1888 Baxter, Andrew, Lime Co., Aberdeen
1876 Bean, Alex., Sunnyside, Rothienorman
1885 Bean, James, Mains of Dumbreck, Udny
1882 Beaton, James, Burnside of Delgaty, Turriff
1885 Beaton, John, Station Hotel, Insch
1876 Beedie, James, The Mains, Ardlaw, Fraserburgh
1894 Begg, Henry F., of Tillyfour, 17 Weighhouse Square, Aberdeen
1876 Bell, John, Tyrie Mains, Fraserburgh
1894 Bennet, Jas., Binghill, Peterculter, by Aberdeen
1888 Bennet, L., Crookednook, Longside
1894 Bennet, Wm., Midplough, Huntly
1858 Benton, William, Harthill, Whitehouse
1885 Black, James, Barthol Chapel, Old Meldrum
1894 Black, Wm., Kinernie, Cluny, Aberdeen
1893 Booth, Matthew, Mastrick Stocket, Aberdeen
1884 Bothwell, Wm., Berryhill, Bridge of Don, Aberdeen
1879 Bowman, James, Square, Huntly
1895 Brand, Robert, Ardiffery, Cruden, Ellon
1886 Brown, James H., Banker, Ellon
1884 Brown, John, Craigie Cottage, Hardgate, Aberdeen
1883 Brown, Joseph, Little Endovie, Alford
1894 Brown, Robert, Mains of Williamson, Culsalmond
1868 Bruce, George, Heatherwick, Keith Hall
1876 Bruce, James, Collithie, Gartly
1868 Bruce, James, Inverquhomery, Mintlaw
1876 Bruce, Peter, Myreton, Insch, Aberdeen
1894 BURNETT, Sir Thomas, of Leys, Bart., Crathes Castle, Aberdeen
1875 Burr, Alexander, Tulloford, Old Meldrum
1895 Butchart, James, Advocate, Aberdeen
1876 Campbell, Silvester, Tofthills, Aberdeen
1894 Cardno, Andrew P., Tillinamoult, New Pitsligo
1894 Cardno, Jas., J.P., Grain Merchant, Fraserburgh
1895 CARNEGIE, Lord, Crimmonmogate, Lonmay
1894 CATHCART, Sir Reginald A. E., Bart., Cluny Castle, Aberdeen
1894 Chalmers, John Lovie, Wester Cardno, Fraserburgh
1894 Chalmers, Wm., Marson Croft, Elrick, Summerhill, Aberdeen
1894 Chapman, William, Woodhead, Aberdour, Fraserburgh
1873 Charles, John, Town and County Bank, Inverurie
1894 Charles, Wm., Gammons, Rothie-Norman
1894 Chessor, James, Craigiebanks, Fraserburgh
1869 CLARK, Sir John F., of Tillypronie, Bart., Tarland
1893 Clarke, John Charles, Meddat, Parkhill, Aberdeen
1873 Clarke, William, Hopewell, Tarland

Admitted
1858 Cochrane, James, Pitlurg House, Slains, Ellon
1893 Cocker, George, Hill of Petty, Fyvie
1894 Cocker, Jas., sen., Sunnypark Nurseries, Aberdeen
1886 Collie, Wm., Priestwells, Insch
1871 Cook, Charles, Carden House, Aberdeen
1894 Cook, Thos. Nicol, Dorsell, Alford, Aberdeen
1894 Cooper, John A., Dunnydeer, Insch
1876 Copland, Alex., Commercial Co., Aberdeen
1891 Copland, Robt., Milton, Ardlethen, Ellon
1840 Cordiner, W. F., Mormond House, Cortes
1894 Cormack, James W., Kinmundy, Summerhill, Aberdeen
1869 Couper, J. C., of Craigiebuckler, Aberdeen
1894 Couper, J. C. Ogston, of Craigiebuckler, Aberdeen
1868 Cowie, Alex., jun., Turtory, Huntly
1884 Cowie, Alex., Ythan Cottage, Ellon
1892 Cowie, W. R., Ythan Cottage, Ellon
1893 Cox, Edmund C., Grandhome House, Aberdeen
1887 Crabb, Dd., New Aberdour, Fraserburgh
1894 Craighead, J. W., Tarbothill, Bridge of Don
1894 Craigie, Wm., Pennan Farm, New Aberdour, Fraserburgh
1878 Cran, George, Old Morlich, Inverkindie
1894 Cran, George, M.D., Walbrook House, Banchory
1876 Cran, James, jun., Knockandoch, Whitehouse
1894 Cromar, Peter, Bogloch, Lumphanan
1858 Cruickshank, Amos, Sittyton, Aberdeen
1868 Cruickshank, Andrew, 37 Gordon Street, Huntly
1876 Cruickshank, J., Ladysford, Fraserburgh
1894 Cruickshank, Jas., Mains of Mayen, Rothiemay
1894 Cruickshank, John, Mains of Balmaud, Fishrie, Turriff
1894 Cruickshank, Robert, Claymires, Turriff
1876 Dakers, James, 24 Union Row, Aberdeen
1886 Darling, D. C., Exchange Square, Aberdeen
1895 Davidson, Adam, Boghead of Denlugas, Turriff
1894 Davidson, Jas., of Holmwood, Aberdeen
1893 Davidson, James, The Mains, Haddo House, Aberdeen
1894 Davidson, James, Newton, Cairnie, Huntly
1894 Dawson, Geo., The Manor Farm, Memsie, Fraserburgh
1886 Dawson, W. F. G., North of Scotland Bank, Insch
1882 Dewar, Alexander, Bethlin, Midmar, Aberdeen
1858 Donald, James, Whitemyres House, Old Skene Road, Aberdeen
1892 Duff, Archibald, of Annfield, Aberdeen
1884 Duff, G. A., of Hatton, Turriff
1868 Duff, Col. James, Knockleith, Turriff
1894 Duff, James Murray, 45 Guild Street, Aberdeen
1858 Duguid-M'Combie, P., of Easter Skene, Aberdeen
1894 Dunbar, A. Duff, V.S., 55 Belmont St., Aberdeen
1886 Duncan, Alexander, Bridge of Dee, Aberdeen
1877 Duncan, John, Fortrie, King Edward
1877 Duncan, Patrick, Balchers, King Edward
1894 Durno, James, Easter Town, Old Meldrum
1879 Durno, James, Jackston, Rothienorman

Admitted
1894 Durno, James, Westertoun, Warthill
1868 Durno, John, Lambhill, Insch
1885 Durno, Leslie, Mains of Glack, Old Meldrum
1891 Durward, Robert, Blelack, Coldstone, Dinnet
1868 Duthie, William, Banker, Tarves
1894 Edmond, John, of Kingswell, Advocate, 16 Bridge Street, Aberdeen
1895 Farquhar, James, Old Echt, Aberdeen
1865 Farquharson, J., 1 Abbotsford Place, Aberdeen
1872 Ferguson, Lieut.-Col. George A., of Pitfour, Mintlaw
1885 Ferguson, Geo. A., Lessendrum, Drumblade
1893 Ferguson, James, jun. of Kinmundy, Mintlaw (10 Wemyss Place, Edin.)
1868 Ferguson, Thomas, 46 Don Street, Old Aberdeen
1870 Ferguson, William, of Kinmundy, Aberdeen (10 Wemyss Place, Edinburgh)
1894 Fiddes, Alex. Harvey, Meikle Haddo, Foveran
1865 Foggo, R. G., Invercauld Office, Ballater
1872 Forbes, Right Hon. Lord, Castle Forbes, Keig
1862 Forbes, The Hon. J. O., of Corse, Lumphanan
1893 Forbes, J. C. Ogilvie, of Boyndlie, Fraserburgh
1874 Forbes, James, Tombreck, Glenbucket
1842 Forbes, General Sir John, of Inverernan, K.C.B., Strathdon
1885 Forbes, William, Ruthven, Dinnet
1874 Fowler, William, of Asleed, Methlick
1885 Fowlie, James, Brucehill, New Deer
1860 Fraser, Col. Fred. Mackenzie, of Castle Fraser, Aberdeen
1885 Fraser, George, Hill of Skillmafilly, Ellon
1892 Fraser, Wm. N., of Findrack, Torphins
1894 Gall, Wm., Smiddyburn, Rothienorman
1874 Garden, Robert, Mains of Tolquhon, Tarves
1857 Garden, William, Strichen, Aberdeen
1882 Garioch, Peter, Broadford House, Aberdeen
1894 Garland, Thos., jun., Ardlethen, Ellon
1882 Garvie, R. G., Hardgate Iron Works, Aberdeen
1886 Geddes, Alex., of Blairmore, Glass, Huntly
1876 Gibson, H. J., 19 Silver Street, Aberdeen
1893 Gibson, Thomas Hayton, Cultercullen, Foveran
1876 Gordon, A. M., of Newton, Insch
1894 Gordon, Charles T., of Cairness, Lonmay
1894 Gordon, Donald, jun., Bovaglie, Ballater
1876 Gordon, Henry, of Manar, Inverurie
1886 Gordon, Henry G. Fellowes, of Knockespock, Clatt
1868 Gordon, H. W., of Hallhead, Ellon
1889 Gordon, Robert, Gordonston, Clatt, Kennethmont—*Free Life Member*
1876 Gordon, William, Auchallater, Braemar
1894 Gordon, Wm. Fowlie, Broomhills, Pitsligo
1889 Grant, Sir Arthur, of Monymusk, Bart.
1876 Grant, John, Banker, Methlick
1895 Grant, P. A. H., of Drumminor, Rhynie
1894 Grant, William, Faichill, Gartly
1820 Grassick, John, 21 Ferryhill Place, Aberdeen
1894 Gray, William, Balgove, Old Meldrum
1894 Gray, William, Keilyford, Old Meldrum
1894 Gray, Wm., Mains of Shedocksley, Old Skene Road, Aberdeen
1890 Hadden, Gavin, Dalmuinzie, Murtle

Admitted
1894 Hadden, Martin L., Binghill, Murtle, Aberdeen
1864 Halkett, Jas., Auchentender, Insch
1876 Hall, Alex. H., 8 Braemar Place
1885 Harper, Hugh (Harper & Co.), Aberdeen
1894 Harvey, Alex. Hunter, Drums, Newburgh, Aberdeenshire
1876 Harvey, G. T., 63 Union Street, Aberdeen
1854 Harvey, J. H., Pitgersie, Foveran, Ellon
1885 Hay, Alexander (Ben. Reid & Co.), Guild Street, Aberdeen
1862 Hay, Col. A. S. L., of Rannes, C.B., Kennethmont
1858 Hay, James, Little Ythsie, Tarves
1894 Henderson, James, Orchard Cottage, Old Aberdeen
1894 Henderson, Sir William, of Devanha, Aberdeen
1893 Hendry, Peter, Hillockhead, Huntly
1894 Howie, Peter, 10 E. North Street, House, Aberdeen
1892 Huggan, John A., 35 Market St., Aberdeen
1876 Hunter, Capt. A. C., of Tillery and Auchiries, Aberdeen
1884 Hunter, Charles, Upper Mills of Drum, Crathes
1894 Hunter, James, 173 King Street, Aberdeen
1872†Huntly, The Marquis of, Aboyne Castle, Aboyne
1884 Hutcheon, Alex., Nether Ordley, Auchterless, Turriff
1886 Hutcheon, Major John, Lower Cotburn, Turriff
1887 Hutcheon, John, of Upperton, Gask House, Turriff
1890 Innes, Lt.-Colonel Francis Newel, R.N., R.A., yr. of Learney, Torphins
1846 Innes, Col. Thos., of Learney, Aberdeen
1862 Innes, T. G Rose, of Netherdale, Turriff
1859 Ironside, William, Clofrickford, Ellon
1894 Jessieman, Robt., Cairnhill, Huntly
1894 Johnston, Charles, Wholesale Merchant, Aberdeen
1894 Johnston, John, Prioryhill, Peterculter
1876 Johnstone, J., Drumwhindle Mains, Ellon
1876 Keith, Alexander, Chapelton, Ellon
1894 Keith, Alexander, Kinnermit, Turriff
1894 Keith, Alex., Spreader Hill, Lonmay
1876 Kilgour, Robert, jun., Ardlin, Ellon
1885 Law, John, Lochend, Old Meldrum
1871 Lawson, Charles, Deebank, Cults
1868 Lawson, C., Ordhead, Cluny, Aberdeen
1876 Ledingham, A., Balnoon Cottage, Forgue, Huntly
1885 Ledingham, John, Fintry, Turriff
1889 Ledingham, J. K., North Plaidy, Turriff —*Free Life Member*
1894 Leggat, Jas. W., Garnieston, Turriff
1890 Leith, A. J. Forbes, of Fyvie Castle, Fyvie
1869 Leith, Major Thomas, Petmathen, Oyne
1885 Leslie, David, Lochhills, New Machar
1885 Leslie, G. Arbuthnott, of Warthill, Aberdeen
1884 Leys, James, Asloun, Alford
1892 Littlejohn, Geo., Wellhouse, Alford, N.B.
1857 Lovie, Alex., Nether Boyndlie, Fraserburgh
1894 Lumley, Theodore, Commissioner, Strichen Estate, Strichen
1877 Lumsden, Gen. Sir H. B., Belhelvie Lodge, Aberdeen
1869 Lumsden, Henry, of Pitcaple, Pitcaple
1877 Lumsden, H. G., of Auchindoir, Aberdeen
1876 Lumsden, W. H., of Balmedie, Aberdeen

Admitted
1894 Lyon, Alex., jun., 278 George Street, Aberdeen
1884 Lyon, John, Peterwell, Fyvie
1895 MacBeth, Jas., Music Seller, Aberdeen
1894 Macdonald, Jas., Bridgend, Mossat, Kildrummy, Aberdeen
1868 Macdonald, R., Cluny Castle, Aberdeen
1894 M'Gregor, Dr, 256 Union Street, Aberdeen
1884 M'Intosh, Jas., 50 Market Buildings, Aberdeen
1880†Mackenzie, Sir A. R., of Glenmuick, Bart., Braiklie House, Ballater
1883 Mackenzie, Wm., 23 Adelphi, Aberdeen
1894 Mackie, Wm , Lewes, Fyvie
1871 Mackie, William, Petty, Fyvie
1894 M'Killigin, Dr, Midtown of Haddo, Turriff
1869 Mackinnon, L., jun., Advocate, Aberdeen
1894 M'Laggan, Jas., Bank Agent, Torphins
1887 M'Lean, Neil, of Breda, Alford, N.B.
1894 M'Leod, Robt., Oakbank Cottage, Aberdeen
1889 Macpherson, And., Gibston, Huntly
1883 M'Robbie, Alex., Sunnyside, Aberdeen
1891 M'Robbie, John S., Sunnyside, Aberdeen
1884 Maitland, John, Easter Balhalgardy, Inverurie
1894 Maitland, Robert Cruickshank, Balhalgardy, Inverurie
1894 Mark, William, 69 George Street, Huntly
1876 Marr, John, Cairnbrogie, Old Meldrum
1855 Marr, Wm. Smith, Upper Mill, Tarves
1888 Marr, W. S., jun., Upper Mill, Tarves
1894 Marshall, Bailie Alexander, Kintore
1885 Matthews, Jas., 255 Union Street, Aberdeen
1891 Mearns, Bailie Danl., Quayside, Aberdeen
1875 Mearns, Rev. Duncan G., Oyne Manse, Aberdeenshire
1892 Mennie, A. M'G., Brawlandknowes, Gartly
1875 Merson, James, Craigwillie, Huntly
1893 Merson, John, Millhill, Gartly
1895 Michie, John, Forester, Balmoral, Ballater
1876 Middleton, Alex., Belmont, Aberdeen
1895 Milligan, D. M. M., 245 Union Street, Aberdeen
1855 Milne, Alex., Lilybank Temperance Hotel, Belmont Road, Aberdeen
1894 Milne, George, Cummings Park, Woodside, Aberdeen
1891 Milne, James, Gateside, Old Meldrum
1894 Milne, James, Pittendrum, Pitsligo, Fraserburgh
1867 Milne, John, Inverurie—*Free Life Member*, 1873
1887 Milne, Robt., Corse of Kinnoir, Huntly
1885 Mitchell, James, Caies Mill, Kinaldie
1894 Mitchell, James S., St John's Well, Fyvie
1876 Mitchell, William, Mains of Billie, Old Deer
1868 Mitchell, Wm. A., Auchnagathel, Keig
1881 Moffatt, Wm., Great N. of S. Railway, Aberdeen
1886 Moir, Alexander, Woodside, Aberdeen
1885 Moir, Robert, Tarty, Ellon
1871 Morris, W., V.S., 7 Langstane Place, Aberdeen
1894 Morrison, Alex. Smith, Stonebriggs, Pitsligo, Fraserburgh
1885 Morrison, Andrew, Upper Cotburn, Turriff
1876 Morrison, John, jun., Hattonslap, Tarves, Old Meldrum
1894 Mowat, John, Craigmaud, by New Pitsligo
1872 Muirhead, George, Haddo House Mains, Aberdeen

Admitted
1894 Murdoch, John, Belnaboth, Glenbucket, Aberdeenshire
1870 Murray, James, Fauchfaulds, Turriff
1894 Murrison, A. R., 13A Correction Wynd, Aberdeen
1894 Mutch, James G., Mains of Rutherstone, Aberdeen
1872 Nares, A. F., Parkhill, Aberdeen
1869 Nicol, W. E., of Ballogie, Aboyne
1885 Nicol, Wm., Ordhead, Cluny, Aberdeen
1882 Norrie, Wm., Cairnhill, Monquhitter, Turriff—*Free Life Member*
1894 Ogg, Charles, Baltimore, Glenbucket
1882 Ogston, Alex. M., of Ardoe, Aberdeen
1894 Park, Wm., Woodhead, Cairness, Lonmay, Fraserburgh
1882 Paull, James, Advocate, Aberdeen
1894 Peters, David Cant, Aberdeen Lime Co., Aberdeen
1894 Philip, John, 2 Kirk Street, Old Meldrum
1894 Philip, William Boynds, Inverurie
1859 Pittendrigh, A., Mains of Park, Lonmay
1894 Porter, Alex., Springhill, Old Skene Road, Aberdeen
1895 Price, Arthur, Cartlehaugh, Mintlaw Station
1895 Price, William, Factor, Aden Estate Office, Mintlaw Station
1898 Profeit, Alex., jun., Dorsincilly, Glenmuick, Ballater
1868 Profeit, Dr, Craigowan Cottage, Balmoral
1894 Pyper, Wm., Hillhead, Aberdeen
1894 Rae, Jas. G., Culterty, Newburgh, Aberdeen
1882 Rae, John, jun., Corn Merchant, Ellon
1882 Rae, Wm., Advocate, Aberdeen
1894 Ramsay, Capt. Burnett, Rifle Brigade, Banchory Lodge, Banchory
1856 Ramsay, Col. John, of Barra, Straloch, Aberdeen
1894 Ramsay, William, jun., Dyce
1891 Reid, David, Crofts of Glenmuick, Ballater
1877 Reid, Dr James, Templeton, Mossat
1858 Reid, James, Westfield Cottage, Alford
1884 Reid, John, Balquharn, Alford, N.B.
1894 Reid, John, Carter, Peterhead
1894 Reid, John Low, Cromlybank, Ellon, Aberdeenshire
1884 Reid, W. R., 137 Union Street, Aberdeen
1885 Reid, Wm., 8 Haddon Street, Aberdeen
1894 Reith, Jas., Mains of Sclattie, Auchmill, Aberdeen
1876 Reith, Robert, Middlefield, Woodside, Aberdeen
1894 Riddell, Geo. Jas., Provost Jamieson's Quay, Aberdeen
1876 Robertson, Duncan, Sheriff of Aberdeen
1885 Robson, Alex. (W. Smith & Sons), Aberdeen
1885 Ronald, Jas., Pitfancey, Forgue, Huntly
1858 Ross, H., care of the Secretary, Mutual Improvement Association, Tarland
1848 Ross, John Leith, of Arnage, Ellon
1871 Ross, Peter, Arngrove, Torphins
1898 Ross, Robt. Robertson, 389 Holburn St., Aberdeen
1871 Ross, Wm., Annesley, Torphins
1885 Runciman, James, Castleton, King Edward
1885 Runciman, John, Auchmull, King Edward
1894 Russell, Col. F. S., C.M.G., of Aden, Mintlaw
1854 Ruxton, Andrew, South Artrochie, Ellon
1894 Ruxton, Chas., Ythan Lodge, Newburgh, Aberdeen

Admitted
1894 Ruxton, George, Langley, Ellon, Aberdeenshire
1886 Saltoun, Right Hon. Lord, Philorth House, Fraserburgh
1894 Scott, Jas., Bruxie, New Maud, Aberdeenshire
1894 Scott, John, Factor and Banker, New Pitsligo
1881 Scott, Ronald, 286 Great Western Road, Aberdeen
1894 Scott, William, Corsiestone, Huntly
1857 Scott, W., Urquhart Road, Old Meldrum
1885 Sellar, R. H. N., Implement Maker, Huntly
1857 Sempill, Right Hon. Lord, Fintray House, Aberdeen
1895 Seton, Major Alexander D., Mounie, Old Meldrum
1894 Sharpe, James Smith, Berryhillock, Premnay
1868 Shaw James, Tillyching, Lumphanan
1894 Shearer, Erit Jas., Maybank Works, Turriff
1865 Shepherd, George, Shethin, Tarves
1894 Shirras, Geo. Findlay, 46 School-hill, Aberdeen
1866 Sim, Alex., 1 Market Street, Aberdeen
1894 Simpson, George, Fernhill, Aberdeen
1894 Simpson, James, Grain Merchant, Rothiemay Station
1885 Simpson, John, Implement Maker, Peterhead
1895 Sivewright, Adam, M.R.C.V.S., Tarland
1856 Skinner, James, Woodside, Aberdeen
1889 Skirving, Robert, of Cobairdy, Huntly
1858 Sleigh, John, Strichen Mains, Strichen
1885 Smith, Arthur, Oakbank Cottage, Kingsgate, Aberdeen
1894 Smith, Duncan M., 27 Argyll Place, Aberdeen
1885 Smith, James, Burnshangie, Strichen
1895 Smith, James, Agent, Northern Agricultural Co., Aberdeen
1885 Smith, J. S., Northern Agricultural Company, Aberdeen
1894 Smith, Robert, jun., Boggieshalloch, Turriff
1894 Smith, W. J. Woodman, 20 King Street, Aberdeen
1858 Stephen, James, Conglass, Inverurie
1880 Stewart, David, of Banchory, Banchory House, Aberdeen
1857 Stewart, Samuel, 44 Whitehall Road, Aberdeen
1885 Still, Alexander W., Nether Anguston, Peterculter
1885 Still, Geo., Strathray, Kinneller, Blackburn, Aberdeen
1894 Stoddart, Geo., Airyburn, Dyce
1893 Stoddart, George, Annfield, Huntly
1883 Strachan, Alex., Wester Fowlis, Alford
1878 Strachan, Charles, Tillyorn, Tarland
1858 Strachan, Lewis, Cluny of Raemoir, Banchory
1894 Strachan, Lewis, Tulloch, Lumphanan
1894 Strachan, Patrick, Eastown, Tarland
1894 Strachan, Wm., Upper Muirden, Turriff
1865 Stuart, Alexander, of Laithers, Turriff
1885 Stuart, E. R. Burnett, of Dens and Crichie, Mintlaw
1895 Stuart, Robert, Wraes, by Insch
1894 Stuart, Wm., Earlsfield, Kennethmont
1876 Tait, John, Crichie, Inverurie
1876 Taylor, James, Toux, Mintlaw
1894 Taylor, J. W., Middle Ardo, Belhelvie
1894 Tennant, Jas., Honeynook, Monquhitter, Turriff
1868 Thompson, George, of Pitmedden, 60 Marischal Street, Aberdeen
1875 Thomson, Wm., Banker, Tarland

Admitted
1894 Tough, George, 70 John Street, Aberdeen
1877 Turnbull, Peter M., Smithston, Gartly
1853 Turner, John, of Turner Hall, Ellon
1873 Udny, J. H. F., of Udny and Dudwick, Aberdeen
1864 Urquhart, B. C., of Meldrum, Old Meldrum
1876 Urquhart, Major F. P., of Craigston, Turriff
1888 Walker, Alex., Gunhill, Inverurie
1884 Walker, David, Coullie, Udny
1881 Walker, George, Port Elphinstone, Inverurie
1877 Walker, James, West Side of Brux, Kildrummy, Aberdeen
1893 Walker, Roderick, Meiklefolla, Rothienorman
1858 Walker, Wm., Ardhuncart, Mossat
1894 Watson, David, Burnthill, Pitsligo, Fraserburgh
1876 Watson, George, Edendiack, Gartly
1894 Watson, Wm., Middlemuir, Aberdour, Strichen
1894 Watt, George, Coralhill, Fraserburgh
1868 Watt, Gordon, Mains of Kebbaty, Sauchen
1889 Watt, John, Newton of Mounie, Daviot, Old Meldrum
1894 Watt, Wm., Grain Merchant, Insch
1894 Wattie, John, Milton, Glenbucket
1894 Webster, James C., Millmoss, Turriff, N.B.
1893 Webster, William, Towie Barclay, Auchterless, Turriff
1894 White, Jas., Legatsden, Pitcaple
1882 Whyte, John, 245 Union Street, Aberdeen
1873 Wilken, George, Waterside of Forbes, Alford
1858 Williamson, A. F., Durno House, Pitcaple, Aberdeen
1850 Williamson, George, 194 King Street, Aberdeen
1894 Williamson, R. D., Bendauch, Dyce
1895 Wilson, Alex. S., 3 Market Square, Old Meldrum
1894 Wilson, C. F., College Street, Aberdeen
1894 Wilson, Geo., Badentyre, Turriff
1865 Wilson, John, Castle Park, Huntly
1885 Wilson, Wm., Coynachie, Gartly
1873 Wilsone, Thomas, Solicitor, Aberdeen
1894 Wood, D. H., V.S., Rothiemay
1838 Yeats, William, of Aquharney, Beaconshill, Aberdeen
1895 Yool, William, Glenlogie, Forbes, Aberdeen
1868 Yull, John S., Little Ardo, Methlick

## BANFF.

1873 Abercromby, Sir R. J., of Birkenbog, Bart., Forglen, Turriff
1885 Alcock, John, Balvenie, Dufftown
1893 Allan, George M., of Montbletton, Banff
1893 Anderson, James, Minmore, Glenlivet
1893 Andrew, William, Rannes, Buckie
1893 Barclay, Geo., Strocherie, King Edward, Banff
1893 Beaton, L., The Farm, Cullen House, Cullen
1893 Bisset, James, of Paddocklaw, Kilnshade, Macduff
1874 Bruce, G., Tochineal, Cullen
1852 Bryson, W. G., Strathlene, Cullen
1894 Cameron, Geo., Bogbain, Keith, N. B.
1875 Campbell, James, Cullen House, Cullen
1887 Cowie, Geo., jun., Pitglassie, Dufftown

Admitted
1894 Craig, William, Easter Gauldwell, Craigellachie
1883 Cran, John, Butcher, Keith
1868 Cumming, George, Writer, Banff
1889 Cumming, J. F., Cardow, Craigellachie
1876 Dawson, William, Gordon Castle, Fochabers
1893 Dey, James, Forkins, Botriphnie, Keith
1893 Donald, George, of Ladyhill, Grange, Keith
1885 Donaldson, George, Auldtown of Netherdale, Aberchirder
1880 Duff, Thomas Gordon, of Drummuir, Keith
1888 Duncan, G. A., Foundry, Banff
1868 Duncan, R., Auchenbaidie Mains, Banff
1888 Duncan, Robert, Banff
1884 Fife, The Duke of, K.T., Duff House, Banff
1879 Findlater, James Smith, 10 Low Street, Banff
1893 Fortune, John, Broom, Portsoy
1894 Fowler, David, Ladysbridge Asylum, Banff
1884 Gilchrist, James, Baker, Banff
1895 Gill, George, of Bloodymire, Macduff
1881 Gordon, John P., of Cairnfield, Fochabers
1876 Gordon, P. G., Nevie, Glenlivet, Ballindalloch
1886 Graham, William, Brewer, Banff
1876 Grant, G. S., Auchorachan, Glenlivet, Ballindalloch
1874 Green, Robert, Ruthrie, Aberlour
1893 Horn, Alex., Brangan, Portsoy
1894 Hutcheson, Wm. Anton, Auchiss, Fordyce, Portsoy
1876 Inkson, Thomas F., Kinermony, Craigellachie
1881 Innes, Sir J., of Balveny and Edingight, Bart., Keith
1893 Johnston, A. G., Distiller, Glenisla, Keith
1883 Kemp, James, Lime Works, Keith
1888 Leith, James, Glengerrack Mains, Keith
1892 Leslie, Alex., Braco House, Keith
1876 Leslie, A. F., Montcoffer House, Banff
1894 Livingstone, William, Newton of Mountblairy, Banff
1894 Longmore, George, Rettie, Boyndie, Banffshire
1885 Longmore, Leith E., Rettie, Banff
1883 M'Donald, Alexander (M'Donald Bros.), Portsoy
1885 M'Donald, Alexander, Kinbrough, Fordyce
1884 MacGillivray, A. E., V.S., Banff
1891 MacIntosh, William, Drummuir, Keith
1876 Macpherson, J., Mulben, Keith
1892 Main, J. G., Barns, Fordyce, Portsoy
1887 Maitland, Harry Reid, Muiryfold, Grange, Keith—*Free Life Member*
1858 Maitland, William, Muiryfold, Grange, Keith
1893 Marsden, Wm. James, V.S., Castle St., Banff
1880 Menzies, W. G. Steuart, Aikenway, Craigellachie
1867 Michie, C. Y., Forester, Cullen House
1874 Miller, John, Seafield, Cullen
1893 Moggach, Joseph, Mains of Towiebeg, Botriphnie, Keith
1893 Morison, Alex. O., Corskie, Banff
1880 Morison, Col. F. D., of Mountblairy, Turriff
1885 Morison, James O., yr. of Culvie, Aberchirder
1885 Morrison, John, Knock, Keith
1893 Murray, Alex., Old Manse, Boyndie, Banff

Admitted
1858 Murray, William, Mains of Pittendreigh, Turriff
1873 Ogilvie, A. M., Tillynaught, Portsoy
1873 Paterson, Wm., Auldtown of Carnousie, Turriff
1892 Raffan, Robert, Knowiemoor, Fordyce
1869 Ramsay, Alex., *Banffshire Journal* Office, Banff
1884 Reid, Wm. T., of Ardmellie, Banffshire
1840*RICHMOND and GORDON, The Duke of, K.G., Gordon Castle, Fochabers
1857 Robertson, William, Port Gordon, Fochabers
1893 Ross, William, Hilton, Buckie
1893 Seafield, Countess-Dowager of, Cullen House, Cullen
1868 Shand, Geo , Ordens, Boyndie, Banff
1883 Simpson, Alexander, Duff House, Banff
1876 Simpson, J. (Auchinachie & Simpson), Keith
1894 Simpson, Thos. A., Colleonard, Banff
1891 Simpson, Wm., Douglasbrae Manure Works, Keith
1894 Skene, John, Montbletton Lodge, Banff
1874 Skinner, Wm. M., Drumin, Ballindalloch
1883 Smith, Alex., Inchcorsie, Rothiemay
1894 Smith, George, Parkmore House, Dufftown
1852 Smith, J. Gordon, Minmore, Ballindalloch
[illegible] Smith, J., Mullochard, Ballindalloch
1894 Smith, Wm., Lagmore, Ballindalloch
1845 Steuart, And., of Auchlunkart, Keith
1887 Stuart, A. R., of Inverfiddich, Craigellachie
1873 Stuart, C., Tomindugle, Knockando, Craigellachie
1894 Taylor, William L., Union Bank, Cullen
1894 Thomson, Wm., Tynet Mills, Port-Gordon
1876 Turner, R., Auchnarrow, Ballindalloch
1883 Turner, Robert, Cairnton of Boyndie, Portsoy
1857 Walker, Francis, Craignetherty, Turriff
1894 Ward, James, Forester, Seafield Estates, Keith
1894 Warrack, Chas. C., of Netherwood, Banff
1876 Wilson, George, Marypark, Ballindalloch
1885 Wilson, James, Inchgower, Fochabers
1893 Wilson, James, of Myrieward, Tenrood, Botriphnie, Keith

## FORFAR

(EASTERN DIVISION).

1889 Adam, John, Bolshan, Arbroath
1893 Adamson, William S., Careston Castle, Brechin
1893 Allison, Archibald, Dubton, Brechin
1884 Anderson, D., Woodhill, Carnoustie
1884 Anderson, James, Mains of Parkhill, Arbroath
1893 Anderson, Jas., Westside, Brechin
1890 Arnot, David, Mains of Edzell, Brechin
1876 Bean, George, West Ballachy, Montrose
1890 Bell, James, Gilchorn, Arbroath
1894 Campbell, Dr Archibald, Keenie, Edzell
1849 Campbell, J. A., of Stracathro, M.P., Brechin
1887 Campbell, Jas. Morton Peto, yr. of Stracathro, Brechin
1886 Carnegie, Alex., of Redhall, Forebank House, Brechin
1869 Carnegie, H. L., of Kinblethmont, Arbroath
1894 Carnegie, James, Arrat, Brechin
1887 Chalmers, P., Aldbar Castle, Brechin
1890 Collier, John W., Hatton, Carnoustie
1879 Colquhoun, Dug., Vitriol Works, Carnoustie

Admitted
1893 Coupar, Andrew, jun., West Kintrockat, Brechin
1859 Coupar, John, Balrownie, Brechin
1870 Cowe, George, Balhousie, Carnoustie
1855 Croll, John, Orchard Park, Broughty Ferry
1874 Cruickshank, Geo., Bryanton, Arbroath
1891 Cruikshank, A. W., of Langley Park, Montrose
1858 Dickson, James A., Woodville, Arbroath
1858 Dickson, J. F., Panbride House, Carnoustie
1875 Duncan, A. R., Rosemount, Montrose
1869 Duncan, Jas., Panlathie Mill, Carnoustie
1862 Erskine, J. E., of Linlathen, Broughty Ferry
1884 Fairweather, John, Chapletown, Brechin
1892 Falconer, James, Milton of Conon, Carmyllie, Arbroath
1894 Farquhar, Alexander, Careston, Brechin
1894 Ferguson, William, Ironmonger, Brechin
1885 Finlayson, James, Balcathie, Arbroath
1890 Fleming, Alex., Charleton, Montrose
1891 Fleming, James, Friock Mains, Friockheim
1890 Fletcher, Fitzroy C., of Letham Grange, Arbroath
1894 Fraser, Andrew, Balmachie, Carnoustie
1890 Gardyne, James W. Bruce, Middleton House, Friockheim
1895 Grant, Colin, Denfield, Arbroath
1893 Hall, George, Caithness Cottage, Carnoustie
1894 Henderson, James, Kincraig, Brechin
1880 Hume, David, Barrelwell, Brechin
1894 Ireland, Thomas, Brewer, Brechin
1858 Jamieson, D., Auchmithie Mains, Arbroath
1894 Jarron, James Alexander, Arbikie, Inverkeillor, Arbroath
1894 Johnstone, John, Balnabreck, Brechin
1890 Kydd, James, Scryne, Carnoustie
1890 Lamb, David, Fithie, Farnell, Brechin
1895 Lyall, Alexander, of Gardyne Castle, Montrose
1854 Lyall, David, of Gallery, Montrose
1881 M'Corquodale, D. A., Banker, Carnoustie
1880 Macfarlane, David, West Haven, Carnoustie
1894 M'Intosh, Thomas, Balquarn, Brechin
1887 MacNab, William, Keithock, Brechin
1889 Miller, James, Balgillo, Broughty Ferry
1889 Miln, George, Solicitor, Arbroath
1894 Milne, Andrew C., Grange, Inverkeillor, Arbroath
1894 Milne, George Gardyne, Montrose
1881 Milne, John, Corn Merchant, Montrose
1879 Mitchell, James, Merchant, Montrose
1881 Mitchell, Wm., Ledmore, Menmuir, Brechin
1868 Morgan, D., South Mains of Ethie, Arbroath
1890 Nicoll, G. F., Chapelton of Leysmill, Arbroath
1884 Nicoll, Wm., Hilton of Fearn, Brechin
1893 Nicoll, William, jun., Mains of Gallery, Montrose
1890 Ogilvie, James Swan, Brackenbrae, Broughty Ferry
1890 Ouchterlony, Lt.-Col. T. H., The Guynd, Arbroath
1885 Pattullo, Jas., Abertay, Broughty Ferry
1891 Pattullo, John, Hatton Mill, Friockheim
1884 Petrie, David D., Friockheim, Arbroath
1891 RAMSAY, Hon. Charles Maule, Brechin Castle, Brechin
1882 Robertson, James, Panmure, Carnoustie
1884 Rodger, Geo., Waulkmills, Inverkeillor, Arbroath

Admitted
1882 Rodger, Robt., jun., Mains of Dun, Montrose
1894 Rodger, John Laurie, Nether Careston, Brechin
1866 Scott, D. G. C., Maisondieu, Brechin
1883 Scott, William, Pitforthie, Brechin
1883 Shepherd, John, Lundie, Brechin
1883 Shield, J. T., Redcastle, Arbroath
1885 Shiell, John, Solicitor, Brechin
1895 Smith, A. Rae, Law of Craigo, Montrose
1889 Smyth, Chas. Armstrong, Dunninald, Montrose
1884 Soutar, D., Powis, Montrose
1890 Souter, John, Auchrennie, Muirdrum, Carnoustie
1850†Southesk, The Earl of, K.T., Kinnaird Castle, Brechin
1880 Stansfeld, Capt. John, Dunninald, Montrose
1892 Stephen, David K., Commieston, Montrose
1894 Swan, Wm. C., Inverpeffer, Carnoustie
1890 Taylor, Robt., Pitlivie, Carlogie House, Carnoustie
1878 Thomson, Alex. M., Arbroath
1876 Vallentine, George, 55 Southesk Street, Brechin
1894 Watson, William, Boddin, Montrose
1894 Wemyss, Dr John W., Broughty Ferry
1874 Wood, Chris., Kintrockat House, Brechin
1884 Young, George, Panlathie, Carnoustie

## KINCARDINE.

1876 Adam, William, Bush, Banchory-Ternan
1857 Anderson, Wm., Hattonburn, Banchory
1894 Annandale, A. B., Bank Agent, Stonehaven
1873 Arbuthnott, Right Hon. Viscount, Arbuthnott House, Fordoun
1881 Baird, Alex., of Urie, Stonehaven
1894 Baird, Henry Robert, of Durris, Aberdeen
1892 Barrie, James, Butcher, Stonehaven
1884 Braid, Thomas, Durris, Aberdeen
1893 Brown, George T., East Cairnbeg, Fordoun
1873 Brown, W., Pitnamoon, Laurencekirk
1894 Bruce, Alex., Mill Inn House, Stonehaven
1894 Calder, Jas., Midtown of Barras, Stonehaven
1858 Calder, R., Raemoir, Banchory-Ternan
1894 Carr, Wm., East Mains of Barras, Stonehaven
1895 Chalmers, G., Craigshaw, Nigg
1888 Chapman, Alexander, Mains of Garioch, Laurencekirk
1871 Clinton, Right Hon. Lord, Fettercairn House, Fettercairn
1884 Cooper, John, Ley, Banchory-Ternan
1892 Cowie, James, Westfield, Stonehaven
1873 Craighead, James, Sillyflat, Bervie
1893 Crichton, William, Castleton of Kincardine, Laurencekirk
1858 Crombie, Alex., Thornton Castle, Laurencekirk
1864 Davidson, J., Harestone, Banchory
1876 Dickson, Patrick, Laurencekirk
1894 Don, Jas., Augwherie, Stonehaven
1873 Falconer, Wm., Cairnton, Fordoun
1894 Forrest, Jas., Westerton, Bridge of Dee
1894 Forrest, Wm., Abbotswell, Kincorth, Nigg
1873 Fortescue, Archer, of Kingcausie, Aberdeen

Admitted
1891 Gammell, Sydney James, yr. of Drumtochty, Fordoun
1876 Gladstone, Sir J. R., of Fasque, Bart., Fettercairn
1860 Grant, Capt. Frederick G. Forsyth, of Ecclesgreig, Montrose
1873 Greig, James Booth, Laurencekirk
1884 Greig, William, Ashentilly, Durris, Aberdeen
1884 Hart, John, Cowie House, Stonehaven
1878 Hay, J. T., of Blackhall Castle, Banchory
1895 Henderson, James, Cheyne, Stonehaven
1884 Hunter, George, Kirktown of Banchory, Banchory-Ternan
1888 Innes, Rev. W. D., of Cowie, Stonehaven
1873 Kinnear, Arthur W., Stonehaven
1876 Kinross, J., Coldstream, Laurencekirk
1876 Kintore, Right Hon. The Earl of, Inglismaldie, Laurencekirk
1876 Littlejohn, William, Easter Tulloch, Stonehaven
1894 M'Gregor, Geo., Mills of Cowie, Stonehaven
1827 M'Inroy, Lieut.-Col. W., of The Burn, Brechin
1893 Martin, James, sen., Farrochie, Stonehaven
1894 Milne, Jas., Balnagubs, Netherley, Muchalls
1894 Milne, James, jun., Easter Cairnhill, Fetteresso, Muchalls
1894 Murray, A. B., Auctioneer, Stonehaven
1885 Murray, J. J., Factor, Fasque, Fettercairn
1894 Myles, John Blythe, Pitcarry, Bervie
1857 Nicholson, J. Badenach, of Glenbervie, Fordoun
1894 Paterson, Jas., Berryhill, Stonehaven
1855 Paul, William, Stranathro Cottage, Muchalls
1863 Pearson, David A., Johnston Lodge, Laurencekirk
1894 Peat, Wm., Westerton, Laurencekirk
1885 Philip, Forbes, Tullos Home Farm, Nigg, Aberdeen
1878 Porteous, D. S., of Lauriston, Montrose
1885 Ross, Alexander, Mains of Newhall, Fetteresso, Muchalls
1859 Scott, Hercules, of Brotherton, Johnshaven
1882 Shand, T. L. R., of Fawsyde, Bervie
1894 Shaw, Charles, Maidenfold, Maryculter
1863 Sinclair, D., of North Loirston, Aberdeen
1876 Skeen, Geo., Meikle Fiddes, Drumlithie
1895 Smith, E. G., Woodbine, Stonehaven
1873 Smith, James, Pittengardner, Fordoun
1873 Smith, John, Balmain, Fettercairn
1868 Smith, W., New Mains of Urie, Stonehaven
1868 Smith, W., of Benholm, Johnshaven
1893 Stewart, George, Haulkerton Mains, Laurencekirk
1858 Taylor, Geo., of Kirktonhill, Montrose
1893 Taylor, John, Uras, Stonehaven
1857 Taylor, Robert, Drumfrenny, Banchory
1894 Thomson, Geo., Kinneskie, Banchory
1868 Thomson, James, Balbegno, Fettercairn
1888 Thomson, W. J. Sandford, Balmanno, Laurencekirk
1888 Trefusis, Hon. Chas. S. Forbes, Fettercairn House, Fettercairn
1863†Walker, G. J., Mains, Portlethen, Aberdeen
1893 Walker, John Wilson, Hillside House, Portlethen, Aberdeen
1892 Walker, Robt. W., Portlethen, Aberdeen

# 6.—DUMFRIES DISTRICT.

EMBRACING THE

COUNTIES OF DUMFRIES, KIRKCUDBRIGHT, AND WIGTOWN.

## DUMFRIES.

Admitted

1879 Aitken, John M., Norwood, Lockerbie—*Free Life Member*
1892 Allan, Alex. Y., Croft Jane, Thornhill
1883 Allan, Wm., 22 High Street, Dumfries
1893 Allison, Colonel William Henry, Park End, Lockerbie
1893 Allison, Hubert, Park End, Lockerbie
1884 Armstrong, John S., Lochside, Dumfries
[illegible] Austin, James J. M., of Dalmakerran, Tynron
1880 Austin, William, Bank Agent, Thornhill
1888 Baird, Alex., West Mains, Collin, Dumfries
1870 Baird, John, Hall, Kirkconnel, Sanquhar
1871 Baird, John, Broomhouses, Lockerbie
1854 Beattie, James, Newbie House, Annan
1870 Beattie, John, Bulmansknowe, Canonbie
1893 Beattie, Lewis, Mossknowe, Canonbie
1878 Beattie, William J. P., Newbie, Annan
1868 Bell, Alexander, Stobahill, Lockerbie
1886 Bell, George, Minsca, Lockerbie
1863 Bell, James, Woodslee, Canonbie
1878 Bell, William, Todholes, Annan
1880 Blacklock, John, Solicitor, Dumfries
1878 Boothby, R. C., Heatheryhaugh, Moffat
1878 Borland, John, Auchencairn, Closeburn, Thornhill
1859 Borthwick, J. J. M., Billholm, Langholm
1898 Brand, David, Hangingshaw, Lockerbie
1878 Broatch, George, Thwait, Ruthwell
1879 Brook, Edward, Hoddam Castle, Ecclefechan
1878 Brown, David, Ellerslie, Kirkmahoe
1860 Brown, James, Hardgrave, Ruthwell, R.S.O.
1886 Brown, James, Burnside, Holywood, Dumfries
1800 Brown, John C., Between-the-Waters, Ecclefechan
1884 Brown, Thomas, Guillyhill, Holywood, Dumfries
1877 Brown, T. M., Closeburn Castle, Thornhill
1865 Campbell, Lieut.-Col. A. H., Kirkland, Thornhill
1893 Carlyle, William Lee, Waterbeck, Ecclefechan
1886 Carmont, James, British Linen Company Bank, Dumfries
1898 Carruthers, Frank James Chambers, of Dixons, Lockerbie
1854 Carruthers, John, of Miln, Wamphray, Moffat
1870 Carruthers, John, Tundergarth, Lockerbie
1876 Carruthers, Joseph, Annan Bank, Moffat
1882 Carruthers, Joseph, Solicitor, Moffat
1870 Carruthers, R. B., Huntingdon Lodge, Dumfries

Admitted

1876 Caven, Thos., Birkshaw, Glencairn, Dunscore
1876 Charlton, Jn., Corn Merchant, Dumfries
1878 Chrystal, William, Gilchristland, Thornhill
1878 Connell, J. W. F., of Auchencheyne, Thornhill
1878 Cormack, John F., Solicitor, Lockerbie
1886 Craig, Alex., Hunter's Lodge, Thornhill
1859 Craig, Wm., Laurel Bank, Dumfries
1872 Cranston, James, Nunwood, Dumfries
1881 Crawford, Jas., Floshend, Gretna
1892 Crawford, Peter, Dargavel, Dumfries
1870 Critchley, J. A., Stapleton Tower, Annan
1892 Dalgleish, John Smith, Auctioneer, Lockerbie
1878 Dalziel, Adam, Chanlockfoot, Penpont
1869 Dalziel, James, Auctioneer, Dumfries
1878 Dalziel, Robert, Druidhall, Penpont
1884 Dickson, George, Braehead, Collin, Dumfries
1862 Dickson, John H., Dabton, Thornhill
1860 Dickson, T., Eccles, Thornhill
1886 Dobie, Alexander, Hitchell, Annan
1878 Dobie, David, Banker, Lockerbie
1868 Douglas, A. H. Johnstone, of Lockerbie, Comlongan Castle, Ruthwell, R.S.O.
1882 Douglas, J., Breconside, Thornhill
1893 Duncan, John Bryce, Newlands, Dumfries
1884 Edmondson, James H., of Riddingwood, Amisfield, Dumfries
1893 Elliot, William, Westwater, Langholm
1874 Erskine, Henry, 16 Henry Street, Langholm—*Free Life Member*
1860 Farish, Samuel, Kirkland, Lockerbie
1877 Farish, Samuel T., Kirkland, Lockerbie
1877 Farish, William R., Tinwald Parks, Dumfries
1878 Fleming, Gavin, Crowdie Knowe, Ecclefechan
1884 Fletcher, D. M., Dunnabie, Ecclefechan
1882 Gillespie, Denholm, 6 Marchbank Terrace, Dumfries
1873†Gillespie, Rev. John, Mouswald Manse, Ruthwell, R.S.O.
1893 Gilmour, Alex., Gairloch, Torthorwald, Dumfries
1895 Gilmour, Thomas Campbell, Liddelbank, Canonbie
1893 Gordon, A. A., Fellside, Moffat
1860 Gordon, Henry, Moatbrae, Dumfries
1898 Graham, Christopher, Skipmyre, Lochmaben
1884 Graham, Major-General John Gordon, of Wyseby, Ecclefechan
1895 Graham, William, Harlawhill, Canonbie
1859 Gray, Alex., Tanlawhill, Langholm
1880 Grierson, Sir A. D., of Lagg, Bart., Dumfries

Admitted
1872 Grieve, Archd., Albierigg, Canonbie
1891 Halliday, James, Slieucairn, Annan
1894 Halliday, Peter, Summerlee, Moffat
1870 Hamilton, John, Leithen Hall, Wamphray
1880 Harkness, W. I., Mitchellslacks, Thornhill
1893 Harper, Robert, Bankhead of Dalswinton, Dumfries
1892 Hayes, John, Dormont Grange, Lockerbie
1887 Henderson, John, Solicitor, Dumfries
1862 Hewetson, J., Auchenbainzie. Thornhill
1870 Hiddleston, John, Kirkland, Closeburn, Thornhill
1895 Hotson, Ninian Wilson, Hopsrig, Langholm
1884 Howat, John, Lower Netherwood, Dumfries
1884 Hunter, James, Lochside, Lockerbie
1886 Hutchison, John, Cresswell House, Dumfries
1880 Hyslop, Wm., Clenries, Sanquhar
1870 Irvine, B., Citra Villa, Lovers' Walk, Dumfries
1883 Irving, D. J. Bell, yr. of Whitehill, Lockerbie
1869 Irving, J. Bell, of Whitehill, Lockerbie
1885 Irving, H. C., of Burnfoot, Ecclefechan
1872 Irving, Samuel, Carco, Kirkconnel
1888 Jardine, Jas. C., Broomhills, Annan
1863†JARDINE, Sir Robert, of Castlemilk, Bart., Lockerbie
1893 Jardine, Robert William Buchanan, yr. of Castlemilk, Lockerbie
1890 Jeffrey, John J., Blackaddie, Sanquhar —*Free Life Member*
1877 Johnston, James, Thistle Cottage, Dumfries
1859 Johnston, Thomas, Moffat
1878 Johnston, Wm., of Cowhill, Dumfries
1886 Johnstone, Andrew J. S., of Halleaths, Broadholm, Lockerbie
1873 Johnstone, James, Hunterheck, Moffat
1859 Johnstone, John A., Archbank, Moffat
1870 Johnstone, J. J. Hope, of Annandale, Raehills, Lockerbie
1881 Johnstone, Michael, Archbank, Moffat
1859 Johnstone, Walter, Alton, Moffat
1863 Kennedy, David, Castlehill, Dumfries
1864 Kerr, Abram, Castlehill, Durrisdeer
1878 Kerr, Archd., Upper Dormont, Lockerbie
1875 Kerr, Jn., Blountfield, Ruthwell, R.S.O.
1893 Keswick, J. J. J., Dormont, Lockerbie
1892 Kirkpatrick, Andrew, Auchengibbert, Crocketford
1875 Kirkpatrick, David, Townfoot, Amisfield, Dumfries
1893 Kirkpatrick, James, Townfoot, Amisfield, Tinwald, Dumfries
1870 Kirkpatrick, James, Auctioneer, Annan
1879 Kirkpatrick, Jas., Rigghead, Torthorwald
1884 Lawrie, John P., Shieldhill, Lochmaben
1878 Lennox, David, Merchant, Dumfries
1865 Leny, W. Macalpine, of Dalswinton, Dumfries
1873 Lindsay, James, Whitecastles, Lockerbie
1869 Little, James, Sark Tower, Canonbie
1878 Little, James Church, Burnfoot, Langholm
1893 Little, James, jun., Sark Tower, Canonbie
1884 Little, John Malcolm, Carlesgill, Langholm
1888 Little, Murray, Solicitor, Annan
1870 Lusk, Andrew, Lochvale, Dumfries
1870 Lyon, Thomas A., Lovers' Walk, Dumfries

Admitted
1887 M'Call, Alexander, Rock Hall Mains, Collin, Dumfries
1870 M'Call, George, Cassalands House, Maxwelltown, Dumfries
1870 M'Call, James, of Caitloch, Moniaive
1878 M'Clure, Wm., Banker, Lockerbie
1868 M'Connel, Fred., of Blackyett, Ecclefechan
1882 MacCowan, A., of Newtonairds, Holywood
1888 M'Creath, John, Comlongan Mains, Ruthwell, R.S.O.
1893 M'Crone, Wm., Castlemilktown, Lockerbie
1887 Macdonald, Alexander, Grain Merchant, Lockerbie
1895 Macdonald, J. C. R., W.S., Dumfries
1893 Macdonald, Major William Bell, of Rammerscales, Lockerbie
1878 Macfarlan, George, Closeburn Mains, Thornhill
1885 M'Gibbon, James R., Union Bank, Moffat
1860 M'Gill, James, Banker, Dumfries
1886 M'Intosh, A. J., V.S., Dumfries
1887 M'Jannet, F. J., Gateslack, Thornhill
1888 M'Jerrow, David, Solicitor, Lockerbie
1894 M'Jerrow, Jas. Ewart, Merchant, Lockerbie
1878 Mackay, D., Greenfield, Kirkpatrick, Ecclefechan
1886 Mackenzie, John A., Solicitor, Lockerbie
1879 M'Kenzie, Neil, Holestane, Thornhill
1860 Mackie, John, Sarkshields, Ecclefechan
1895 M'Leod, William, Bank Street, Dumfries
1870 M'Millan, John, of Glencrosh, Moniaive
1895 M'Millan, Samuel, Bank of Scotland, Moffat
1886 M'Nae, Robert, V.S., Dumfries
1878 M'Tier, John, of Ladyfield, Dumfries
1840 Malcolm, W. E., of Burnfoot, Langholm
1880 Martin, William, Dardarroch, Dumfries —*Free Life Member*
1889 Maxwell, Chas. H., Dalruskin, Dumfries
1870 MAXWELL, Sir John R. Heron, of Springkell, Bart., Ecclefechan
1878 Maxwell, George, of Broomholm, Langholm
1882 Maxwell, Joseph, Seedsman, Thornhill
1867 Maxwell, Maxwell Hyslop, of The Grove, Dumfries
1886 Millar, Wm., Lakehead, Closeburn, Thornhill
1878 Milligan, James, Hayfield, Thornhill
1870 Milligan, John, Auldgirth, Dumfries
1886 Milne, Thomas, Grain Merchant, Lockerbie
1870 Minto, John D., Dumfries
1870 Mitchell, Joseph M., Burnscairth Green, Dumfries
1893 Moffat, James, Gateside, Sanquhar
1862 Moffat, Thomas, Sunnyhill, Dumfries
1883 Moffat, Wm., Garwald, Langholm
1878 Monilaws, Rev. James J., Middlebie Manse, Ecclefechan
1878 Murray, Allan, Castlemilk Mill, Lockerbie
1886 Newbigging, Thos. Kennedy, Nurseryman, Dumfries
1890 Osborne, Robert, Wynholm, Lockerbie
1893 Park, Robert, Factor, Dryfesdalegate, Lockerbie
1889 Paterson, Francis, Clerkhill, Langholm
1885 Paterson, John S., Craigdarroch, Sanquhar
1854 Paterson, J. W. J., Terrona, Langholm
1884 Paterson, Robert, of Robgill Tower, Ecclefechan

Admitted
1885 Paterson, Wm., E. Craigdarroch, Sanquhar
1886 Paterson, Wm., Rock Hall, Dumfries
1893 Pender, James, Morton Mains, Thornhill
1892 Pilkington, L., Cavens, Dumfries
1884 Primrose, John, Solicitor, Dumfries
1869 QUEENSBERRY, The Marquis of, Kinmount, Annan
1884 Rain, Rev. Thos., Hutton Manse, Lockerbie
1874 Ranken, John S., Lawesknowe, Moffat
1886 Rannie, D. W., of Conheath, Dumfries
1881 Richardson, John, Braehead, Heck, Lockerbie
1878 Richardson, William, Milnfield, Annan
1884 Richardson, Wm., Cotland, Dumfries
1893 Robson, John, County Buildings, Dumfries
1884 Roddick, Frank, Trailtrow, Ecclefechan
1894 Rome, H. F., High Street, Annan
1893 Scott, Chas. C., Breconside, Moffat
1878 Scott, Robert A., Kirkbank, Dumfries
1893 Scott, William Black, Ashley Bank, Langholm
1877 Semple, Wm., Mouswald Banks, Ruthwell, R.S.O.
1878 Sloan, James, Coachbuilder, Dumfries
1883 Sloan, Hugh, Gillenbie, Lockerbie
1877 Smith, Robert, Dalfibble, Dumfries
1870 Smith, Thomas, Twiglees, Lockerbie
1859 Steuart, Patrick, Middlegill, Moffat
1860 Stewart, Peter, Dornock Mains, Annan
1886 Stobo, James, Halliday Hill, Auldgirth
1878 Struthers, Wm., Logan Mains, Canonbie
1886 Symons, John, Solicitor, Dumfries
1870 Taylor, Joseph, Potholm, Langholm
1878 Thompson, Alexander, Ironmonger, Dumfries
1869 Thomson, J. S., of Brae, Dumfries
1878 Thomson, Robert, of Brae, Dumfries
1878 Thomson, William, M'Cheynston, Auldgirth
1878 Todd, Alex., Mouswald Grange, Ruthwell, R.S.O.
1890 Underwood, Wm., Ironmonger, Annan
1873†Villiers, F. E., Closeburn Hall, Thornhill
1894 Vivers, William, Dornocktown, Annan
1858 Walker, Sir George G., of Crawfordton, Thornhill
1886 Wallace, James R. W., Auchenbrack, Thornhill
1889 Wallace, John William, Wallace Hall, Auldgirth
1885 Wallace, William, of Whitewoollen, Lockerbie
1875 Waugh, John, Granton, Moffat
1886 Whitelaw, James W., Solicitor, Dumfries
1884 Whittle, John, Kinnelhead, Moffat
1869 Wightman, John Seton, of Courance, Lockerbie
1880 Wilson, George, Nunholm, Dumfries
1870 Wilson, James R., Banker, Sanquhar
1878 Wilson, John, Tinwaldshaws, Tinwald, Dumfries
1878 Wilson, P. M'C., Nether Gribton, Dumfries
1877 Wright, Thomas, Bengall, Lockerbie
1864 Yorstoun, M. C., of Tinwald, Irvine House, Canonbie
1891 Young, John, Moffat

## KIRKCUDBRIGHT.

1889 Adamson, John, of Craigadam, Dalbeattie
1870 Anderson, Robert, Alleyford, Kirkgunzeon

Admitted
1894 Armitage, Arthur Calrow, of Kirroughtree, Newton-Stewart
1889 Barbour, Wm., Troquhain, New Galloway
1884 Barrowman, John H., Caigton, Castle-Douglas
1871 Bell, William, of Gribdae, Kirkcudbright
1878 Berwick, John, Whiteside, Kirkgunzeon
1878 Biggar, James, Grange Farm, Dalbeattie
1858 Biggar, Thos., of Chapelton, Dalbeattie
1886 Biggar, Wm., Chapelton, Dalbeattie
1886 Blackett, Lieut.-Col. C. E., of Arbigland, Dumfries
1878 Brown, John Gordon, Lochanhead, Dumfries
1870 Brown, Joseph, Hermitage, Dalbeattie
1861 Brown, Oliphant, Dalry, Galloway
1864 Brydon, James, Nether Ervie, Parton, Castle-Douglas
1892 Caird, James A., of Cassencary, Creetown
1892 Campbell, John, care of Johnstone, Hamilton Place, Castle-Douglas—*Free Life Member*
1885 Campbell, Robert J.. Cuil, Castle-Douglas—*Free Life Member*
1888 Campbell, Thomas, V.S., Kirkcudbright
1879 Cannon, James, Urioch, Castle-Douglas —*Free Life Member*
1877 Cannon, John, Rosebank, Dalbeattie
1874 Chalmers, Archd., of Kipp, Dalbeattie
1884 Clark, S. T., Netherthird, Castle-Douglas
1890 Cliff, Edward A., Mabie, Dumfries
1860 Corrie, Adam, South Park, Kirkcudbright
1860 Craig, Joseph, of Threecrofts, Lochrutton, Dumfries
1878 Craik, Geo., Argrennan Mains, Tongland
1894 Crawford, Hugh W. B., Hall of Auchencairn, Castle-Douglas
1866 Cuninghame, R. D. B., of Hensol, Castle-Douglas
1864 Cunningham, Jas., Tarbreoch, Dalbeattie
1889 Cunningham, John, Durhamhill, Dalbeattie
1879 Currie, John, Kirkeoch, Kirkcudbright
1878 Douglas, Wm. D. R., of Orchardton, Castle-Douglas
1877 Dudgeon, R. F., The Grange, Kirkcudbright
1889 Duncan, James, East Glenarm, Crocketford, Dumfries
1884 Dunlop, Captain H. L. Murray, of Corsock, Dalbeattie
1871 Dunlop, Robert, Dryburgh, Castle-Douglas
1886 Farish, James, Lincluden Mains, Dumfries
1889 Fergusson, Robert W., of Kilquhanity, Dalbeattie
1859 Frazer, John, Maxwellfield, New Abbey, Dumfries
1860 Gibson, J. T., Tullowquhairn, Kirkbean
1884 Gibson, Robert, Hightae, Castle-Douglas
1888 Gillespie, William, Solicitor, Castle-Douglas
1886 Gilmour, W. P., Balmangan, Kirkcudbright
1886 Gordon, Alexander J., Kirkcudbright
1885 Gordon, Edward, Keltonhill, Castle-Douglas
1877 Gordon, James, Castle-Douglas
1879 GORDON, Sir William, of Earlston, Bart., Kirkcudbright
1878 Gray, Adam, Ingleston of Borgue, Kirkcudbright
1859 Grierson, Joseph, Breoch, Castle-Douglas
1859 Grierson, Wm., 41 Queen Street, Castle-Douglas

Admitted
1876 Hayman, John, Queenshill, Ringford
1878†Herries, Right Hon. Lord, Kinharvey, New Abbey
1858 Herries, A. Y., of Spottes (16 Heriot Row, Edinburgh), Dalbeattie
1878 Hood, David A., Balgreddan, Kirkcudbright
1884 Hood, Wm., Chapelton, Borgue
1886 Hope, John, Commander R.N., St Mary's Isle, Kirkcudbright
1878 Houston, John, The Hill, Castle-Douglas
1895 Howat, Andrew, Burnside of Mabie, Troqueer, Dumfries
1886 Hughan, Major Henry H., of Airds, Parton, N.B.
1880 Hutchison, Graham, of Balmaghie, Castle-Douglas
1879 Hutchison, J. W., of Edinghame, Castle-Douglas
1870 Hyslop, And., Auchenreoch, Dalbeattie
1886 Jamieson, John, Jameston House, Carsphairn
1871 Kay, D. J., of Drumpark, Dumfries
1846 Kennedy, J. L., of Knocknalling, Dalry, Galloway
1878 Kennedy, J. M., yr. of Knocknalling, Dalry, Galloway
1890 Kerr, Jas., Mid-Kelton, Castle-Douglas —*Free Life Member*
1860 Kerr, Thos., Kirkchrist, Kirkcudbright
1891 Kirwan, Major Wm. F. Maitland, of Gelston, Castle-Douglas
1878 Kirwan, L. M., Collin, Auchencairn
1848 Laurie, W. K., of Woodhall, Castle-Douglas
1864 Lidderdale, W. H., Writer, Castle-Douglas
1889 Livingston, Alexander, 89 High Street, Dalbeattie
1878 M'Conchie, John, Carsewilloch, Creetown
1878 M'Cormick, John, Lochenkit, Corsock, Dalbeattie
1876 MacKerrow, M. S., Boreland of Southwick, Dumfries
1878 M'Kie, John, of Bargaly, Castle-Douglas
1882 Mackie, John Gladstone, of Auchencairn, Castle-Douglas
1878 M'Kinnel, William, Butterhole, Dalbeattie
1876 M'Larin, Dugald, Dalbeattie
1879 M'Nab, R. W., Banker, Dalbeattie
1870†M'Queen, James, of Crofts, Dalbeattie
1876 M'Taggart, John, Culnaightry, Castle-Douglas
1878 M'Turk, W. A., Barlae, Dalry, Galloway
1888 M'William, John, Carantyne Villa, Dalbeattie
1885 Marshall, Wm., Loch Fergus, Kirkcudbright
1878 Maxwell, George, of Glenlee, New Galloway
1878 Maxwell, James, Screel, Castle-Douglas
1878 Maxwell, W. J., Terregles Banks, Dumfries
1879 Maxwell, Wellwood, of Kirkennan, Dalbeattie
1839†Maxwell, Wellwood H., of Munches, Dalbeattie
1886 Maxwell, Sir W. F., of Cardoness, Bart., Gatehouse
1878 Maxwell, W. J., yr. of Munches, M.P., Terraughtie, Dumfries
1893 Milligan, J. M., Waterside, New Galloway
1878 Mitchell, Andrew, Barcheskie, Kirkcudbright
1867 Moffat, James, of Kenervie, Banker, Castle-Douglas
1878 Montgomery, And., of Netherhall, Castle-Douglas

Admitted
1879 Montgomery, John, Comstonend, Twynholm
1878 Montgomery, William, Banks, Kirkcudbright
1886 Morris, Christopher, of Barons Craig, Dalbeattie
1893 Morton, David, Cally, Gatehouse
1878 Muir, James, Lochfergus, Kirkcudbright
1877 Muir, Wm., Craigville, Kirkcudbright
1879 Murray, B. R., of Parton, Castle-Douglas
1879 Murray, G. R., yr. of Parton, Castle-Douglas
1890 Nicholson, William, Bombie, Kirkcudbright
1878 Nivison, Stewart, Lairdlaugh, Dalbeattie
1878 Ovens, Walter, Torr House, Castle-Douglas
1870 Paterson, D. J., Cowar, Kirkgunzeon
1889 Picken, David L., Milton, Kirkcudbright
1883 Rae, William, Halldykes, Rotchell Park, Dumfries
1870 Rain, Wm., Kempleton, Twynholm
1894 Russell, Wm., Barend, Castle-Douglas
1883 Shennan, John K., Balig, Kirkcudbright
1883 Shennan, R., Balig, Kirkcudbright
1857 Skirving, Adam, of Croys, Dalbeattie
1882 Smith, Jas., Standingstone, Twynholm, Castle Douglas
1877 Spalding, A. F. M., of Holm, New Galloway
1870 Sproat, R., Lennox Plunton, Kirkcudbright
1878 Sproat, W. T., Borgue House, Kirkcudbright
1857 Stewart, H. G. Murray, of Broughton, Gatehouse
1886 Stewart, Robert, of Culgruff, Crossmichael
1878 Stewart, Captain William, of Shambellie, Dumfries
1868 Symington, G. C., Kirkcarswell, Kirkcudbright
1889 Taylor, James, Meikle Ernambrie, Castle-Douglas
1884 Templeton, Matthew, Dromore, Kirkcudbright
1869 Thomson, John, Laggan, Gatehouse
1886 Timms, H. A., of Slogarie, New Galloway
1878 Veitch, Andrew, Girthon Kirk, Gatehouse
1879 Wallace, J., Foundry, Castle-Douglas
1886 Wallace, M. G., Terreglestown, Dumfries
1879 Wallace, R., Foundry, Castle-Douglas
1870 Wallace, R., Langbarns, Kirkcudbright
1886 Wallet, John, Auction Mart, Castle-Douglas
1879 Williamson, A., Meikle Spyland, Kirkcudbright
1890 Williamson, Captain Cecil H., Carlingwork, Castle-Douglas
1871 Williamson, Thos., Merchant, Kirkcudbright
1878 Wylie, Wm., Pleasance of Cargen, Dumfries

## WIGTOWN.

1893 Adair, John, Springbank, Stranraer
1893 Agnew, Patrick Alex. Vans, of Sheuchan and Barnbarroch, Whauphill
1875 Agnew, William, Balwherrie, Stranraer
1893 Aitken, Alex., Solicitor, Church Street, Stranraer
1878 Anderson, Charles, Barsalloch, Port William
1893 Anderson, John, Anabaglish, Kirkcowan
1893 Anderson, John, Drummoral, Isle of Whithorn

Admitted
1864 Anderson, Peter, King's Arms Hotel, Glenluce
1893 Baird, William, Kirvennie, Wigtown
1878 Barbour, Robert, Balgowan, Ardwell, Stranraer
1893 Bennoch, James, Sheuchan, Castle-kennedy
1893 Bennoch, John, Solicitor, Stranraer
1878 Black, Thomas, Craigencrosh, Stranraer
1878 Broadfoot, Peter, West Mains, Kirkinner
1893 Brown, John, Bridgehouse, Sorbie
1891 Cairns, Thomas M., Kildarroch, Kirk-cowan, Wigtown
1890 Campbell, Robert, jun., Craichmore, Stranraer
1898 Christison, James, Barglass, Kirkinner
1893 Clanachan, Robert, Little Genoch, Dun-ragit
1898 Cochran, George, North Cairn, Kirkcolm
1877 Cochran, Robert, Caldons, Stoneykirk
1893 Cochran, Robert, Portencallie, Kirk-colm
1885 Cochran, William, Auchentibbert, Sand-head, Stranraer
1898 Cochrane, James, Barscarrow, Sandhead
1869 Cowan, George, Mains of Park, Glenluce
1893 Craig, Robert Joseph, Innerwell, Gar-lieston
1870 Drew, James, of Craigencallie, Newton-Stewart
1893 Drew, James Lawson, Dranandow, New-ton-Stewart
1891 Drynan, Thomas Wallace, Carscreugh, Glenluce
1893 Fergusson, James, Back-of-Wall, Glen-luce
1893 Findlay, Francis, Farmer, Appleby, Glas-serton
1893 Findlay, Francis, Cutcloy, Isle of Whit-horn
1893 Findlay, John Wood, Bailliewhir, Whit-horn
1878 Forsyth, John, Reiffer Park, Sorbie
1857 Frederick, D., of Gass, Stranraer
1809 Frederick, Robt., Drumflower, Dunragit
1877 Frederick, Thomas, Cairnhandy, Stoney-kirk
1860 GALLOWAY, Right Hon. The Earl of, Gal-loway House, Garlieston
1898 Gibson, William, Broch, Stranraer
1871 Gourlay, R. C., Arbrack, Whithorn
1880 Greig, T. C., Rephad, Stranraer
1898 Hannay, John, Ponton, Garlieston
1878 Hardie, J., jun., Mull of Galloway, Stran-raer
1893 Haswell, Robert, Challochmurr, Glen-luce
1848 HAY, Sir J. C. D., of Park Place, Bart., Glenluce
1877 Hughan, Peter H., Cults, Whithorn
1885 Hunter, James, Culgroat, Stranraer
1888 Hunter, Wm., Garthland Mains, Stran-raer
1893 Kerr, George, Solicitor, Newton Stewart
1898 Kerr, Hugh, West Galdenoch, Stoney-kirk
1893 Kerr, Matthew, Craiglemine, Glasserton
1893 Kerr, Thomas, Banker, Newton-Stewart
1867 Lang, Alex., Boreland, Glenluce
1895 Lennox, Thomas, New Milns, Wigtown
1878 Lockhart, James, Mains of Airies, Stran-raer
1878 Logan, David, Fernbank, Stranraer
1877 Lusk, Peter, Craigcaffie, Stranraer
1888 M'Caig, John, Challoch, Leswalt, Stran-raer
1887 M'Caig, John, High Mye, Stoneykirk
1898 M'Caig, R. Stewart, Kilhilt, Stranraer
1875 M'Camon, John, Kirronrae, Stranraer
1892 M'Clean, James, Auchneal, Stranraer

Admitted
1892 M'Clelland, And., Glenturk, Wigtown
1878 M'Clew, David A., Chapel Rossan, Stran-raer
1878 M'Conchie, A., Mains of Penninghame, Newton-Stewart
1893 M'Conchie, Samuel, Risk, Newton-Stewart
1893 M'Connel, James, Boreland, Whauphill
1857 M'Connell, J. A., Chapelheron, Whithorn
1878 M'Connell, Thomas M., V.S., Wigtown
1882 M'Connell, Wm., Glassnick, Kirkcowan
1877 M'Cosh, Peter, Cairngawn, Kirkmaiden
1884 M'Cracken, Robt., Creamery, Dunragit
1893 M'Creath, Thomas, Skaith, Newton-Stewart
1870 M'Culloch, John, Glenhead, Stranraer
1878 M'Culloch, Peter, Whitefield, Glenluce
1865 M'Douall, James, of Logan, Stranraer
1870 M'Dowall, Andrew, Auchtialure, Stran-raer
1878 M'Dowall, R., Auchengallie, Port Wil-liam
1893 M'Dowall, William Hutcheson, Seeds-man, &c., Kirkcowan
1895 M'Garva, William, The Cottage, Ardwell, Stranraer
1893 M'Geoch, Thomas, Barncaughlaw, New-ton-Stewart
1893 M'Gibbon, William, Ivy House, Stran-raer
1893 M'Gill, Andrew, Barsalloch, Wigtown
1893 M'Gill, Andrew, Kildonan, Stoneykirk
1893 Macgregor, William, V.S., Stranraer
1870 M'Haffie, Wm. J., of Torhousemuir, Wig-town
1871 M'Ilraith, Thomas, Barwhanny, Kirk-inner
1878 M'Ilwrick, Alex., Quarter, New Luce
1893 M'Keand, Alex. Forsyth, Carseriggan, Kirkcowan
1880 M'Keand, P., Airlies, Whauphill
1893 M'Lean, Charles Arbuthnot, Solicitor, Wigtown
1860 M'Lean, James, Clerk of Supply, Wig-town
1857 Maclelland, Thos., North Balfern, Kirk-inner
1874 M'Master, Allan, Dinvin, Portpatrick
1871 M'Master, Hugh, Blairbuy, Port William
1878 M'Master, James, Currochtree, Stranraer
1875 M'Master, John, Culhorn Mains, Stran-raer
1875 M'Master, William, Challoch, Dunragit
1889 M'Master, Wm., junior, Cruggleton, Gar-lieston
1893 M'Naught, Alex., Hawthorn, Changue, Port-William
1893 Mathieson, William, Mindork, Kirk-cowan
1878 Matthews, A. B., British Linen Bank, Newton-Stewart
1877 MAXWELL, Sir H. E., of Monreith, Bart., M.P., Whauphill, N.B.
1887 Menzies, W. M., Cults, Castle Kennedy
1893 Milroy, James, Craig, Whithorn, N.B.
1875 Milroy, James, Galdenoch, Stoneykirk
1876 Milroy, John, Balgreggan Mains, Stran-raer
1891 Murray, Alex., Kilfillan, Glenluce
1893 Murray, William, Borrowmoss, Wigtown
1893 Nicholson, Andrew, Kidsdale, Whithorn
1893 Niven, John F., Mahaar, Kirkcolm
1893 Parlane, John, Craigdhu, Glasserton
1893 Pettigrew, James, Larg, Newton-Stewart
1860 Picken, R., Barnkirk, Newton-Stewart
1893 Porteous, Andrew, Kirkland, Leswalt
1885 Ralston, Robert, Greyhill, Stoneykirk
1883 Ralston, Wm. H., Culmore, Stranraer
1878 Rankin, Alex., Aird, Stranraer
1893 Robertson, James, Clendrie, Kirkcolm

Admitted
1878 Routledge, C. M., Banker, Port William
1878 Routledge, J. J. F., Old Mill, Port William
1870 Routledge, Wm., Elrig, Port William
1893 Salomon, William Thomas, Cornwall Park, Newton-Stewart
1893 Shaw, David Burnie, Garlieston
1878 Smith, William, Garvarie, Port William
1893 Sprott, James, Dhuloch, Leswalt
1845†STAIR, The Earl of, K.T., Lochinch, Castle Kennedy Station
1891 Stevenson, Robert, Balcarry, Glenluce
1893 Stevenson, Robert, Glenside, Kirkcolm, Stranraer
1892 STEWART, Major-General The Hon. Alex., of Corsbie, Newton-Stewart
1869†STEWART, Sir M. J., of Southwick, Bart. M.P., Ardwell
1846 Stewart, R. H. J., of Physgill and Glasserton, Whithorn
1868 Symington, Gilbert, Glenluce

Admitted
1893 Symington, Thomas, Solicitor, Glenluce
1893 Taylor, Peter, Inchpark, Stranraer
1893 Templeton, Thomas, Auchinleck, Newton-Stewart
1871 Thompson, Alex., Barmeal, Port William
1893 Thorburn, John, Port-of-Spittle, Stoneykirk
1869 Todd, William, Auchness, Ardwell
1893 Tully, William, Colfin, Stranraer
1890 Wallace, James A., Claycrop, Kirkinner
1887 Watson, Allan Thomson, Genoch, Dunragit
1870 Whyte, James A., Kirkmabreck, Stranraer
1878 Wither, James, Lagganmore, Portpatrick
1894 Wither, Thos., Awkirk, Lochans, Stranraer
1885 Wright, Hugh, of Alticry, Port William
1860 Young, J. A., Orchardtown, Garlieston
1893 Young, William, Culnoag, Sorbie

# 7.—INVERNESS DISTRICT.

EMBRACING THE

COUNTIES OF CAITHNESS, ELGIN, INVERNESS, NAIRN, ORKNEY AND SHETLAND, ROSS AND CROMARTY, AND SUTHERLAND.

## CAITHNESS.

Admitted
1874 Adam, Thomas, of Lynegar, Wick
1865 Brims, James, Thurso
1874 Brock, John, Princes Street, Thurso
1892 Brown, George, Watten Mains, Watten
1894 Dunnet, Alex., Upper Gillock, Wick
1894 Ferrier, Jas., Ackergill Mains, Wick
1893 Geddes, Alex., Implement Maker, Wick
1847 Henderson, Alexander, of Stemster, Thurso (30 Palmerston Pl., Edinburgh)
1883 Henderson, David P., yr. of Stemster, Halkirk, N.B.
1874 Henderson, A. W., of Bilbster, Wick
1883 Henderson, Captain J. H., Rosebank, Wick
1881 Horne, Edward Wm., of Stirkoke
1892 Innes, Donald, Borlum, Reay, Thurso
1873 Irvine, G. F., Shrubbery Bank, Thurso
1871 M'Beath, James, Brims, Thurso
1861 Miller, John, of Scrabster, Thurso
1894 Morris, Robt., Reis Lodge, Wick
1881*†Portland, His Grace The Duke of, Langwell, Wick
1861 Purves, James, Barrogill Mains, Wick
1869 Purves, William, Thurdistoft, Thurso
1884 Robertson, Robert, Implement Maker, Wick
1881 Sandison, M., Hempriggs, Wick—*Free Life Member*
1894 Seton, Robert S., Rampyards, Walten—*Free Life Member*
1892 Sinclair, Alex., Quoys of Reiss, Wick
1857 Sinclair, Sir J. G. T., of Ulbster, Bart., Thurso Castle, Thurso
1880 Sinclair, Sir John R. G., of Dunbeath, Bart., Barrock House, Wick
1864 Sinclair, Sir Robert C., of Stevenson, Bart., Achvarsdale Lodge, Reay, Thurso
1855 Smith, James, of Olrig, Thurso
1870 Sutherland, Alex., Rampyards, Watten—*Free Life Member*
1862 Tait, Wm. Reid, Murkle Estate Office, Thurso
1871 Waters, George S., Tistermains, Halkirk Road

## ELGIN.

1889 Adam, John, Coulardbank, Lossiemouth
1893 Adam, Wm., Chemical Works, Burghead
1893 Anderson, George H., Ironmonger, Elgin
1884 Anderson, Robert, Viewfield, Elgin
1871 Black, James, of Sherriffston, Elgin
1893 Brander, James, Pittendreich, Elgin
1893 Brown, James, Miltonhill, Alves, Forres
1871 Brown, William, Earlsmill, Forres—*Free Life Member*, 1873
1878 Bruce, D. C., Byres, Fochabers

Admitted
1864 Bruce, George, Woodside, Elgin
1884 Brydon, John, Forester, Rothes
1893 Clark, Donald, Blervie Castle Farm, Forres
1871 Colvin, James E., Wester Manbeen, Elgin
1850 Creyk, Dr A., Dalvey, Advie, Strathspey
1894 Creyk, Geo., Dalvey, Advie Station
1878 Cruickshank, David, Meft, Elgin
1875 Cruickshank, John, Pond Park, Craigellachie
1874 Cumming, Sir Wm. G. Gordon, of Altyre, Bart., Forres
1895 Dean, Alex., Jointurelands, Elgin
1894 Dean, Wm., Milton Brae, Elgin
1839 Dunbar, Sir Archibald, of Northfield, Bart.
1894 Dunbar, Jas., Shinnoch, Cromdale
1888 Edgar, James, Nether Bogside, Elgin
1893 Fettes, John, Westertown, Fochabers
1893 Fettes, William, Corskie, Garmouth
1893 Forbes, Robert, Woodhead, Forres
1893 Fraser, William, Waterford Mills, Forres
1893 Fraser, William, Waterfolds, Elgin
1859 Garden, Arch., of Bernery, Forres
1890 Gilchrist, Wm., Leuchars, Elgin
1860 Gordon, George, Land Surveyor, Elgin
1895 Gordon, R. A., Orchard Cottage, Rothes
1893 Grant, Charles, Salterhill, Elgin
1859*†Grant, Sir George Macpherson, of Ballindalloch, Bart.
1894 Grant, Jas., of Glen Grant, Rothes
1894 Grant, John, Bogg, Advie
1883 Grant, John Macpherson, yr. of Ballindalloch, Milton Cottage, Kingussie
1870 Grant, J., Mains of Advie, Advie
1871 Grant, John, Inverlaidnan, Carr Bridge
1894 Grant, Robt., Farmer, Cromdale
1893 Grant, Wm. R. (Buenos Ayres), Tullochgribbon, Grantown
1880 Haddon, P. M., St Mary's, Orton, Fochabers
1883 Henderson, Peter, Factor, Ballindalloch
1864 Hunter, John, Dipple, Fochabers
1888 Hutcheson, James, W.S., Elgin
1893 King, William, Kingsmills, Elgin
1893 Knight, John, Kintrae, Duffus, Elgin
1895 Laing, William, Wallfield, Urquhart, Elgin
1893 Law, Arthur Woodland, Sanquhar Farm, Forres
1874 Lawrence, James, Forres Mills, Forres
1893 Leitch, Andrew, East Grange, Forres
1858 Leitch, A. K., Inchstelly, Forres
1893 M'Culloch, Alexander, Ardivot, Lossiemouth
1886 M'Gregor, Captain James, Balmenach, Cromdale
1883 Macdonald, Wm., Carsewell, Alves

Admitted
1870 Mackay, H. M. S., Banker, Elgin
1870 Mackay, R. J., Burgie Lodge, Forres
1882 Mackenzie, F. C., Forres
1886 Mackenzie, Thomas, Carron, Strathspey
1893 Mackessack, Charles, Asleask, Forres
1893 Mackessack, Chas., Wester Alves, Forres
1882 Mackessack, George R., yr. of Ardgye and Roseisle, Ardgye, Elgin
1865 Mackessack, James, Earnside, Forres
1874 Mackessack, John, Kinloss, Forres
1864 Mackessack, Robert, of Ardgye and Roseisle, Ardgye, Elgin
1882 Mackessack, R. H., Newton of Struthers, Forres
1893 Maclean, George A., Hythehill, Elgin
1891 MacLeod, Captain Norman, of Dalvey, Forres
1876 M'William, James, Stoneytown, Keith
1893 Matheson, William, Muirton House, Kinloss, Forres
1893 Mathieson, Alex., Doonpark, Forres
1893 Mavor, George, Cluny, Forres
1893 Mavor, John, Leckiehill, Forres
1894 Munro, Alex., The City Hotel Stables, Elgin
1894 Mutch, Jas., Deanshaugh, Elgin
1894 Neish, Wm., Merchant, Multen, Boharm
1894 Peterkin, Jas., 18 South Street, Elgin
1875 Peterkin, James Grant, of Grange, Forres
1894 Petrie, David, Gilston, Elgin
1871 Petrie, George, Rosehaugh, Elgin
1883 Petrie, George, Pitairlie, Elgin
1876 Petrie, W. A., Rosebrae, Elgin
1873 Reid, Alexander, Architect, Elgin
1895 Reid, Jas., Maverston, Urquhart, Elgin
1895 Reid, John, Gladhill, Garmouth, Elgin
1893 Robertson, Hugh, Balnageith, Forres
1895 Robertson, John, Bank of Scotland, Elgin
1874 Robertson, William, Linkwood, Elgin
1870 Robertson, Wm. A., Mayfield, Forres
1883 Russell, Alex., Myreside, Elgin
1893 Scott, Hugh, Dallas, Forres
1874 Scott, Robert, Easter Manbeen, Elgin
1895 Sellar, William, Longhill, Elgin
1893 Shiach, Gordon Reid, Surgeon Dentist, Elgin
1893 Simpson, William, Cowfords, Fochabers
1894 Smith, Wm., The Pans, Elgin
1893 Stephen, Alexander, Coxton, Lhanbryde, Elgin
1894 Stewart, John, Rynballich, Cromdale
1893 Stuart, James, Garbity, Orton, Elgin
1895 Stuart, James, Glen Spey Villa, Rothes
1893 Stuart, John Paul, Orbliston, Fochabers
1877 Sutor, James, The Collie, Fochabers
1893 Tait, James, V.S., Forres
1874 Thomson, J. Grant, Grantown
1883 Thurlow, Right Hon. Lord, Dunphail, Forres
1882 Urquhart, Robert, jun., Forres
1859 Walker, Robert, Altyre, Forres
1864 Walker, Wm., Auchray Buildings, Elgin
1883 Watson, H. A., U.P. Manse, Forres—*Free Life Member*
1875 Watt, James, Surradale, Westfield, Elgin
1881 Wedderspoon, James, Fochabers
1870 Wight, Alexander, Ironmonger, Forres
1864 Yool, Thomas, Calcots, Elgin
1852 Young, Alex., Findrassie House, Elgin
1871 Young, James, Waterton, Elgin

## INVERNESS.

1865 Anderson, James, Solicitor, Inverness
1889 Anderson, William, Solicitor, Inverness
1886 Baillie, A. C., Dochgarroch, Inverness
1883 Baillie, James E. B., of Dochfour, Inverness

Admitted
1880 Baird, John, of Knoydart, Inverie House, Ornsay, Skye
1891 Barron, James, Editor of the *Inverness Courier*, Inverness
1882 Baxter, Frederick, Seedsman, Inverness
1883 Bethune, Angus, Seafield, Inverness
1883 Birnie, Alex., Wellhouse, Beauly
1892 Birnie, John, Balnafettack, Inverness
1874 Biscoe, T. Ramsay, of Newton, Kingillie, Inverness
1883 Black, Robert, C.E., Inverness
1874 Blair, Patrick, Sheriff-Substitute, Inverness
1892 Boyd, Donald, Merchant, Fort-William
1891 Cameron, Angus, Ben Nevis Auction Mart, Fort-William
1859†Cameron, Donald, of Lochiel, Auchnacarry, Fort-William
1895 Cameron, Francis, Lower Muckovie, Inverness
1890 Cameron, James, Coulnakyle, Nethy Bridge, R.S.O.
1892 Cameron, James T., Tallisker, Carbosk, Skye
1891 Cameron, John, Culreach Mains, Nethy Bridge, R.S.O.
1892 Cameron, Robert D., Lochgorm, Inverness
1884 Campbell, A. D., of Kilmartin, Glen Urquhart
1891 Cattell, James, Balnaglack, Petty, Inverness
1865 Chisholm, Duncan, 42 Waterloo Place, Inverness
1874 Chisholm, John, 8 Academy Street, Inverness
1871 Cran, John, Kirkton, Bunchrew, Inverness
1893 Davidson, John, Home Farm, Guisachan, Beauly
1865 Davidson, Robert, Queensgate, Inverness
1883 Davidson, Samuel, Beechhill, Inverness
1883 Dick, W. G., Horse-hirer, Inverness
1865 Dougall, Andrew, Railway Manager, Inverness
1887 Duncan, James, Fern Villa, Inverness
1862†Dunmore, Right Hon. The Earl of, Isle of Harris
1874 Elliot, Matthew, Flesher, Inverness
1890 Ferguson, Fergus, Monkstad, Uig, Portree
1865†Forbes, Duncan, of Culloden, Inverness
1894 Fraser, Alexander, Balloch, Culloden, Inverness
1894 Fraser, Alex., Solicitor, Inverness
1874 Fraser, Alexander, Commercial Bank, Inverness
1857 Fraser, Alex., Sheriff-Substitute, Portree
1893 Fraser, Andrew, Ashton, Inverness
1883 Fraser, David, Dalneigh, Inverness
1889 Fraser, Donald, of Millburn, Inverness
1853 Fraser, Hugh, Balloch of Culloden, Inverness
1894 Fraser, Hugh Ernest, M.B., C.M., Inverness
1874 Fraser, James, C.E., Inverness
1874 Fraser, James, Mauld, Beauly
1865 Fraser, William, Annfield, Inverness
1893 Garland, William, Delshangie, Glen Urquhart
1892 Garrioch, J. T., Lovat Estates Office, Beauly
1871 Grant, John, Inverlaidnan, Carr Bridge
1886 Grant, John Brown, Erchless, Beauly
1894 Grant, John Peter, of Rothiemurchus (Inverichnie, Banff)
1874 Grant, Major Wm., Drumbuie, Glen Urquhart
1883 Grant, Wm. R., Solicitor, Inverness

Admitted
1854 Gregory, A. A., 1 Ardross Terrace, Inverness
1875 Guild, James L., Strowan, Inverness
1882 Gunn, Alex., V.S., Beauly
1886 Honeyman, Thos., Auchnacarry, Fort-William
1865 Howden, John, Inverness
1883 Howe, Thomas, Parks of Inshes, Inverness
1875 Hugonin, R., Kinmylies House, Inverness
1874 Innes, Charles, Solicitor, Inverness
1883 Jones, R. E., Fassfern, Fort-William
1874 Kelman, William, Wester Lovat, Beauly
1889 Kemble, Major, Knock, Skye
1890 Kennard, Cecil, Tormore, Broadford, Skye
1883 Laurie, Robert, Eilean Cottage, Drumnurn, Inverness
1853 Lawson, Wm., 13 Ardconnel Terrace, Inverness
1891 Linton, Andrew, Inchree, Onich, N.B.
1894 Livingston-Macdonald, Captain R. M., 3rd Seaforth Highlanders, Flodigarry, Isle of Skye
1892 MacAinsh, John, Congash, Grantown
1891 Macallister, Thomas S., Inverness
1873 MACANDREW, Sir Henry C., The Castle, Inverness
1892 M'Bain, Wm., Piterrald, Drumnadrochet
1865 M'Bean, D., Auchterblair, Carr Bridge
1895 M'Bean, Daniel, Cradle Hall, Inverness
1883 M'Bean, Wm., Cradle Hall, Inverness
1889 Maccoll, Rev. Canon Hugh, Rosse Parsonage, Fort-William
1883 Macdonald, Alex., Balintore, Bogroy
1884 M'Donald, Alex., Portree
1874 Macdonald, A. R., Ord, Isle of Ornsay
1883 Macdonald, Allan, Solicitor, Inverness
1883 M'Donald, Charles, Knocknageal, Inverness
1893 M'Donald, D. D., Drumnadrochet, Glen Urquhart
1889 Macdonald, Hugh, Coach Proprietor, Fort-William
1891 Macdonald, J. H., Charleston, Inverness
1846 Macdonell, E. R., of Morar, Fort-William
1893 Macdonell, James, Sidgreaves, Camusdaroch, Morar, Arisaig
1865 MacEwen, John C., Inverness
1893 Macfarlane, And., Viewfield, Kingussie
1870 M'Gillivray, Allan, Banchor, Kingussie
1892 M'Gillivray, Hugh, Cattle-dealer, Inverness
1871 M'Gillivray, John, Ballachroan, Kingussie
1876 MacGillivray, William, Eoligary, Barra
1877 M'Gregor, Archd., Glenforslan, Salen, Ardgour
1891 M'Intosh, Charles, Craggie, Inverness
1889 M'Intosh, Donald, West End Hotel, Fort-William
1880 MacIntosh, James, Factor, Ostaig, Isle Ornsay, Skye
1875 Mackenzie, Alexander, Silverwells, Inverness
1878 Mackenzie, Alex., Banker, Beauly
1893 M'Kenzie, Alex., C.E., Kingussie
1891 Mackenzie, Dr Murdo T., Scolpaig, North Uist
1874 Mackenzie, N. B., British Linen Bank, Fort-William
1886 Mackenzie, Wm. D., of Farr, Inverness (Fawley Court, Henley-on-Thames)
1883 Mackintosh, A. D., of Mackintosh, Moy Hall, Inverness
1866 Mackintosh, C. Fraser, of Drummond, Inverness
1846 Mackintosh, Æneas, of Balnespick, Inverness

Admitted
1844 Mackintosh, Æneas W., of Raigmore, Inverness
1814 Mackintosh, A., of Holme, Inverness
1883 Mackintosh, Hugh, Ironmonger, Inverness
1875 Maclean, Charles, Milton, Lochmaddy
1875 M'Leish, Daniel, Bank of Scotland, Fort-William
1893 M'Lennan, Alex., Beechwood, Inverness
1883 M'Millan, E. H., Caledonian Bank, Inverness
1878 Macpherson, C. J. B., of Beleville, Kingussie
1887 Macpherson, Col. Ewen, of Cluny Macpherson, Kingussie
1870 Macpherson, Colonel Lachlan, of Glentruim, Newtonmore
1888 Macpherson, L. A., of Corrimony, Inverness
1883 Macrae, Alex. D., Ruthven, Kingussie
1891 Macrae, Horatio Ross, W.S., of Clunes, Inverness (57 Castle St., Edinburgh)
1874 Macrae, Roderick, Postmaster, Beauly
1888 MacTavish, Alex., Implement Maker, Inverness
1869 Malcolm, George, Craigard, Invergarry
1892 Malcolm, John, Craigard, Invergarry.
1883 Manners, C. R., C.E., Inverness
1883 Marr, Alex., Dalcross, Fort-George Station
1865 Martin, John, Docharn, Boat of Garten, Strathspey
1880 Martin, Nicol, of Glendale, Dunvegan
1883 Merry, A. W., of Belladrum, Beauly
1888 Merry, C. J., Belladrum, Beauly
1874 Mitchell, Andw., Royal Bank Buildings, Inverness
1864 Munro, D., Milton, Fort-George Station
1874 Munro, John, Seedsman, Inverness
1892 Murray, Francis, Butcher, Inverness
1890 Nicholson, Arthur Wm., Arisaig House, Fort-William
1893 Oberbeck, C., Central Restaurant, Inverness
1887 Orde, A. G. Campbell, yr. of Kilmory, Newton, Lochmaddy
1888 Paterson, Donald, Askernish, South Uist, Oban
1854 Peter, John, Croyard, Beauly
1883 Roberts, Wm., Dell of Inches, Inverness
1888 Roberts, Wm., Highland Railway Co., Inverness
1874 Robertson, John, of Greshornish, Portree
1894 Robertson-Macleod, K. M., of Greshornish, Isle of Skye
1890 Rose, Hugh Francis, of Holme Rose, Fort-George
1865 Rose, James, Mains of Connage, Fort-George Station
1865 Rose, John, Leanach, Inverness
1883 Ross, Alex., Architect, Inverness
1865 Ross, George, Owen Cottage, Ballifeary Road, Inverness
1883 Ross, James, Solicitor, Inverness
1888 Ross, Wm., Seafield of Raigmore, Inverness
1892 Scott, David, Auctioneer, Inverness
1890 Shaw, Alexander, Farraline Mains, Inverness
1883 Shaw, Duncan, W.S., Inverness
1891 Sinton, P. J., Glennevis, Fort-William
1865 Smith, John, Inverallan House, Grantown
1892 Stewart, C. D., of Brin, Inverness
1884 Stewart, D. A., Ensay, Obbe
1887 Stewart, J. C., Glenmoidart, Moidart
1852 Stewart, John, of Ensay, Scorrybreck, Portree
1883 Stirling, John, of Fairburn, Muir of Ord
1883 Stuart, W. G., Inverness

Admitted
1875 Trotter, R., Garguston, Muir of Ord
1884 TWEEDMOUTH, Right Hon. Lord, Guisachan House, Beauly
1883 Tytler, Edward G. F., of Aldourie, Inverness
1889 Urquhart, Farquhar, Seedsman, Inverness
1875 Walker, Geo. A., Torbreck, Inverness
1883 Walker, George, Wood Merchant, Inverness
1886 Watson, James, 29 Southside Road, Inverness
1891 Weir, James, Achnacarry, Fort-William

## NAIRN.

1856 Anderson, Robert, of Lochdhu, Nairn
1892 Brown, Gilbert, Midcoul, Fort-George Station
1878 Cameron, Dr James Angus, of Firhall, Nairn
1839 CAWDOR, Right Hon. The Earl of, Cawdor Castle, Nairn
1891 Clark, James, Golford, Nairn
1883 Clarke, Lieut.-Col. M. A., Achareidh, Nairn
1883 Donaldson, H. T., Banker, Nairn
1891 Fiddes, George, Drumduan, Nairn
1892 Finlay, R. B., of Newton, Q.C., Nairn
1893 Fraser, Major, Dunlichtily, Strathnairn, Nairn
1852 Fraser, William, of Kilmuir and Newton, Nairn
1894 Gowans, Charles F., Newton of Budgate, Cawdor, Nairn
1895 Grant, James Augustus, of Househill, Nairn
1865 Joss, John, Budgate, Cawdor
1872 Macdonald, Donald, The Park, Nairn
1874 MacGregor, R., Fern Cottage, Nairn
1886 M'Intyre, Donald, Meikle Kildrummie, Nairn
1883 Mackillican, P., Achagour, Nairn
1891 M'Lennan, Alex., Milton of Kilravock, Nairn
1891 Malcolm, William, Househill, Nairn
1874 Mather, John Arres, Delnies, Nairn
1891 Methven, Edward W., Hazelbrae, Nairn
1885 Mill, George, Piperhill, Nairn
1892 Robertson, John, Horse-hirer, Nairn
1873 Robertson, John S., Cawdor Estate Office, Nairn
1894 Robertson, Wm., Tomlunquhart, Nairn
1865 Rose, Major James, of Kilravock, Fort-George Station
1894 Russell, James, Blackhills, Nairn
1892 Smith, Alex., Cantraydown, Fort-George Station
1894 Squair, Geo., Kildrummie, Nairn
1889 Walker, John Mackintosh, of Geddes, Nairn

## ORKNEY AND SHETLAND.

### ORKNEY.

1854 Burroughs, Lieut.-General F. W. Traill, C.B., of Rousay
1870 Cromarty, William, Widewall, So. Ronaldshay
1894 Davidson, Wm. Henry Bain, Kirkwall
1872 Drever, Jas., Swanny House, Finstown
1884 Fortescue, William I., Swanbister, Kirkwall
1875 Gibson, John, Langskaill, Rousay
1888 Hossack, B. H., Craigiefield, Kirkwall
1879 Johnstone, James, Orphir House, Orphir
1878 Learmonth, D. H., Housebay, Stronsay

Admitted
1877 Leitch, Simon, Elwickbank, Shapinsay
1887 Maxwell, Henry, How, Sanday
1884 Reid, Alfred, Braebuster, Kirkwall
1884 Scarth, Robert, Binscarth, Kirkwall
1886 Sinclair, Thomas, Whitehall, Stronsay
1884 Stephen, Donald, Northtown, Birsay
1877 Stevenson, William, Holland, Stronsay
1894 Tait, John, Papdale, St Ola, Kirkwall
1878 Watt, W. G. T., Kierfiold House, Stromness

### SHETLAND.

1884 Anderson, Gilbert, Hillswick, Lerwick
1863 Bruce, John, of Sumburgh, Lerwick
1892 Edmonston, Laurence, Hallegarth, Baltasound, Lerwick
1875 Edmondston, Mrs, of Buness, Unst, Lerwick
1892 Ganson, Robert D., Lerwick
1874 Hamilton, W. Cameron, Baltasound, Unst
1881 Hamilton, Zachray Macaulay, Baltasound, Unst
1876 Jaffray, James, Belmont, Unst
1886 Manson, Anderson, Laxfirth, Lerwick
1891 Manson, Peter, Lunna, Shetland
1892 Pottinger, Sinclair, Grimsta, Lerwick
1876 Sandison, Alexander, Uyasound, Unst

## ROSS AND CROMARTY.

1855 Adam, Æneas, Humberston, Dingwall
1893 Adam, Hugh R., Balvaird, Muir of Ord
1870 Allan, William, Drummondreoch, Ferrintosh, Conon Bridge
1895 Anderson, John Norrie, Stornoway
1883 Anderson, T. A., Ballachraggan, Alness
1862 Arras, Walter, Fodderty, Dingwall
1889 BELL, Sir William James, of Scatwell, Muir of Ord
1892 Bignold, Arthur, of Loch Rosque, Achnasheen
1893 Binning, James, Keppoch, Dingwall
1893 Binning, John, Banker, Dingwall
1893 Brown, John, M.R.C.V.S., Invergordon, Ross-shire
1886 Brown, Stephen, Killilan, Lochalsh
1887 Brown, Rev. W. L. Wallace, The Manse, Alness
1883 Cameron, Archd., Killen, Avoch
1883 Cameron, Colin M., Balnakyle, Munlochy
1869 Cameron, Duncan, Banker, Tain
1881 Cameron, Duncan, Fettes, Muir of Ord
1891 Campbell, G. J., Sheriff-Substitute, Stornoway
1894 Dallas, Alex. J., Solicitor, Tain
1865 Darroch, Duncan, of Gourock Torridon, Achnasheen
1861 Douglas, Thomas, Mains of Rhynie, Fearn
1874 Douglas, William, Arboll, Fearn
1895 Dudgeon, Alex. Harper, Woodlands, Dingwall
1892 Duncan, William J., Solicitor, Dingwall
1884 Fletcher, J. D., of Rosehaugh, Inverness
1893 Forbes, Lachlan, Culcraigie, Alness
1855 Forsyth, John, Balintraid, Invergordon
1883 Fowler, J. A., yr. of Braemore, Inverbroom House, Garve
1893 Fraser, Donald, Balintore, Fearn
1893 Fraser, Donald, Balintore Hotel, Fearn
1886 Fraser, John G., Easter Rarichie, Fearn
1893 Fraser, Malcolm F., Balaldie, Fearn
1892 Gallie, Abner, Morangie, Tain
1874 Goodbrand, James H., Culnaha, Nigg
1874 Gordon, J. A., of Arabella, Nigg
1875 Gordon, John, Cullisse, Nigg

Admitted
1853 Grant, Kenneth, Craigellachie, Strathpeffer
1893 Grant, William, Rarichie, Nigg
1893 Gunn, Edmund J., Solicitor, Dingwall
1892 Gunn, John, of Aldie, Tain
1875 Gunn, William, Strathpeffer, Dingwall
1898 Gunn, William Fred., Nutwood, Strathpeffer
1894 Henderson, Alexander, Merchant, Dingwall
1883 Henderson, James, Culcairn, Invergordon
1884 Henderson, John, Factor, Fortrose
1889 Henderson, Thomas, Assistant Factor, Fortrose
1879 Inglis, George, of Newmore, Invergordon
1885 Jackson, Major Randle, of Swordale, Evanton
1893 Johnstone, James, Merchant, Balintore, Fearn
1892 Linton, John, Castle Craig, Nigg
1883 Littlejohn, Alex., of Invercharron, Ardgay
1893 Logan, David, Auchtertyre, Lochalsh
1892 Lovat, Lord, Beaufort Castle, Beauly
1889 Lumsden, John Wm., Navity, Cromarty
1892 Macdonald, Alex., Rhives, Delny
1893 Macdonald, Donald, Wilkhaven, Portmahomack
1893 Macdonald, John, Hilton, Portmahomack
1895 M'Farlane, Robert, Tornich, Invergordon
1874 MacGregor, James G., Fearn
1875 MacIntyre, Robert, Newton, Evanton, N.B.
1875 M'Intyre, P. B., Mains of Findon, Conon Bridge
1893 M'Intyre, William, Stittenham, Alness
1877 Mackay, Henry, Shandwick Mains, Nigg
1893 Mackay, William, Brucefield, Portmahomack
1893 Mackay, William Wallace, Wester Arboll, Fearn
1892 Mackenzie, Sir A. G. Ramsay, of Coul, Bart., Strathpeffer
1872 Mackenzie, Andw., of Dalmore, Alness
1895 Mackenzie, A. F., Inverbreakie, Invergordon
1883 Mackenzie, Colin Lyon, of St Martins, Braelangwell, Invergordon
1865 Mackenzie, James Fowler, of Allangrange, Munlochy
1854†Mackenzie, Sir Kenneth S., of Gairloch, Bart., Conon House, Conon
1892 Mackenzie, Murdo, Banker, Invergordon
1894 Mackenzie, Capt. T. A., yr. of Ord House, Muir of Ord
1883 Mackenzie, William, Kinnairdie, Dingwall
1875 Maclennan, Alexander, Leanassie, Lochalsh
1888 M'Rae, Ewen M., Kinbeachie, Conon Bridge
1878 MacRaw, Donald, Moultavie, Alness
1887 Matheson, Sir Kenneth J., of Ardross, Bart., Alness
1892 Meiklejohn, John J. R., Novar, Evanton
1892 Methuen, John, Balmacara, Lochalsh
1881 Middleton, Lord, Applecross, Lochcarron
1875 Middleton, A. A., Rosefarm, Invergordon
1864 Middleton, George, Cornton, Dingwall
1893 Middleton, George, jun., Docharty, Dingwall
1872†Middleton, Jon., Davidston, Invergordon
1872 Middleton, Jon., Clay of Allan, Fearn
1893 Middleton, Thomas, Farness, Invergordon
1880 Middleton, T. H., Rosefarm, Invergordon—*Free Life Member*
1893 Middleton, Walter Ross Taylor, Solicitor, Dingwall
1875 Mitchell, Andrew, Ratagan House, Lochalsh
1881 Mundell, Walter, Moy, Muir of Ord
1870 Mundell, W. G., Inverlael, Lochbroom
1883 Munro, Sir Hector, of Foulis, Bart., Dingwall
1893 Munro, Hector, V.S., Fearn
1877 Munro, John, of Lemlair, Dingwall
1892 Munro, Stuart C., of Teananich, Alness
1891 Murdoch, Alex., Dalnavie, Alness
1875 Murdoch, James, Drynie Mains, Inverness
1884 Murray, Charles, of Lochcarron, Dingwall
1883 Murray, William, Bellfield, Inverness
1857 Murray, William, Kilcoy, Killearnan
1892 Ness, Charles, Auchindunie, Alness
1893 Paterson, Alex., Ardullie, Dingwall
1874 Paterson, Wm. G., Ord, Invergordon
1879 Peterkin, W., Dunglass, Conon Bridge
1884 Pirie, A. G., of Leckmelm, Ullapool
1884 Reid, N., New Kelso, Strathcarron, Ross-shire
1869 Robertson, Chas., of Kindeace, Invergordon
1893 Robertson, J. M., Ankerville, Nigg
1895 Robertson, John Cameron, Achilty, Strathpeffer
1874 Robertson, John, Mounteagle, Fearn
1892 Ross, Lady, of Balnagown, Parkhill
1894 Ross, Baillie, Tain
1893 Ross, A. M., Editor of the *North Star*, Dingwall
1895 Ross, Donald, Balnagore, Fearn
1872 Ross, George, Merchant, Dingwall
1893 Ross, George A., Rhynie, Fearn
1893 Ross, George, Brompton, Fearn
1893 Ross, Hugh, Banker, Tain
1876 Ross, James, Pollo, Delny, R.S.O.
1874 Ross, John, Meikle Tarrel, Fearn
1893 Ross, John, Railway Contractor, Fearn
1892 Ross, John F., Pitcalnie, Nigg
1884 Ross, William, Kinnahaird, Strathpeffer
1887 Ross, W. C., of Cromarty
1892 Scott, James, Seafield, Portmahomack
1892 Sellar, Patrick, Hartfield, Tain
1892 Shoolbred, Walter, of Wyvis, Evanton
1893 Simpson, David William, Arcan Mains, Muir of Ord
1864 Smith, Alexander P., Munlochy Farm, Munlochy
1892 Stewart, William, Alness Ferry, Resolis, Invergordon
1891 Stirling, Major William, yr. of Fairburn, Kinellan Lodge, Strathpeffer
1888 St Quintin, Geoffray Aspley, Cromarty
1895 Stuart, David, Estate Office, Munlochy
1894 Urquhart, Thos., of Delny, C.E. of Delny Station
1891 Walker, William, Contullich, Alness
1868 Warrand, Major A. J. C., Ryefield, Ferintosh
1892 Wilson, Hugh, Milton of Noth, Rhynie
1875 Young, James, Cadboll, Fearn
1894 Yule, Peter A., Ussie Cottage, Maryburgh

## SUTHERLAND.

1865 Barclay, Thomas, Skelbo Castle, Dornoch
1893 Box, John, Tongue, Sutherland
1870 Brebner, Robert, Skibo Mains, Dornoch
1884 Cameron, Alexander, Drumuie, Golspie
1893 Campbell, J. R., Shinness, Lairg

Admitted
1883 Clarke, G. G., Eriboll, Lairg
1856 Dudgeon, John B., Crakaig, Loth
1888 Gunn, John, The Hermitage, Golspie
1851 Hill, Robert, Navidale House, Helmsdale
1874 Hill, Robert Robertson, Navidale House Helmsdale
1854 Houstoun, Wm., Kintradwell, Brora
1850 M'Iver, Evander, Scourie House, Lairg
1890 Mackintosh, John, Proncy, Dornoch

Admitted
1888 M'Lean, Donald, Dunrobin, Golspie
1847 Marshall, John, Clebrig, Lairg
1844 Menzies, Duncan, Blairech, Lairg
1874 Mitchell, James R., Culgower, Loth
1863 Mitchell, Wm., Ribigill, Tongue
1874 Mundell, John, Dalchork, Lairg
1893 Rose, Alex., Coul, Dornoch
1889 Scott, James, Durness
1883 Shaw, James T., Gordonbush, Brora
1885 Urquhart, John, Cambusavie, Dornoch

# 8.—BORDER DISTRICT.

EMBRACING THE

## COUNTIES OF BERWICK, PEEBLES, ROXBURGH, AND SELKIRK.

### BERWICK.

Admitted
1892 Aitchison, Wm., Kames, West Mains, Greenlaw
1854 Allan, John, Peelwalls, Ayton
1893 Bertram, George William, Heughead, Reston
1874 Bertram, John, Addinston, Lauder
1854 Bertram, John S., Cranshaws, Duns
1866 Bolam, Robt. George, Berwick-on-Tweed
1885 BOSWALL, Sir G. Houstoun, of Blackadder, Bart., Chirnside
1867 Bromfield, W. J., Old Greenlaw, Greenlaw
1891 Broomfield, George L., Solicitor, Lauder
1854 Broughton, R. H., of Rowchester, Greenlaw
1888 Brown, Colonel, Longformacus, Duns
1893 Brown, Robert, Cammo Foundry, Duns
1872 Brownlie, Alex., Haughhead, Earlston
1883 Brydon, Thos. T., Burncastle, Lauder
1884 Calder, T. A., Billie Mains, Chirnside
1872 Calder, W. A., Oxenrig, Coldstream
1880 Carmichael, John, Coldstream
1884 Caverhill, A. M., 3 North Terrace, Berwick
1860 Chirnside, G., Edrington House, Berwick
1889 Cookson, C. L. Stirling, Renton, Grant's House
1884 Cossar, Mark, Greenknowe, Duns
1872 Cowe, Peter, Butterdean, Grant's House
1870 Cowe, Robert, Old Castles, Chirnside
1883 Cranston, Robert, Pathhead, Cockburnspath
1881 Craw, H. H., West Foulden, Berwick
1857 Darling, Adam, Governor's House, Berwick
1880 Darling, Thomas, 1 Palace Street East, Berwick
1887 Deas, Adam, Briery Bank, Duns
1882 Dickenson, Robert, Longcroft, Lauder
1859 Dickenson, Wm., Longcroft, Lauder
1891 Dodds, Robt., Blackadder Bank, Chirnside
1863 Dodds, William, Elwartlaw, Greenlaw
1863 Dryden, William, Coldstream
1884 Dunn, James, Blainslie, Lauder
1880 Edington, Wm., Dowlaw, Coldingham, Ayton
1854 Elder, W., Implement Works, Berwick-on-Tweed
1893 Elliot, Frank, Middlestots, Duns
1884 Elliot, William, Ellemford, Duns
1882 Ferguson, J., Duns Castle Estate Office, Duns
1884 Fulton, John, Hatchednize, Coldstream
1893 Galbraith, Chas. E., Ayton Castle, Ayton
1878 Gibb, Robert Shirra, Boon, Lauder—*Free Life Member*, 1885
1864 Gibson, J., Fairlaw House, Reston
1893 Gillies, John, Edington Mills, Chirnside
1882 Gilroy, James, Berwick-on-Tweed

Admitted
1894 Goodfellow, Alex., Todrig, Greenlaw—*Free Life Member*
1894 Grieve, Andrew, Flass, Lauder
1892 Haldane, Fred, Bareless, Cornhill-on-Tweed
1880 Henderson, Robert, East Gordon, Gordon
1881 Herbertson, Robert H., Fans, Earlston
1893 Hogg, George, Blackhouse, Edrom
1892 Hogg, Robert, Fireburn Mill, Coldstream
1854 Hogg, Thomas, Hope Park, Coldstream
1893 Hogg, Wm., jun., Clackmae, Earlston
1860 HOME, Right Hon. The Earl of, The Hirsel, Coldstream
1874 Home, Col. D. Milne, of Wedderburn, Paxton House, Berwick
1895 Home, David William Milne, yr. of Wedderburn, Paxton House, Berwick
1880 Hood, James, Cove, Cockburnspath
1854 Hood, T., Coldstream Mains, Coldstream
1884 Hood, Thos., Factor, Coldstream
1877 Hood, W., The Cove, Cockburnspath
1879 Hope, A. Peterkin, Sunwick, Berwick
1886 Hope, Col. Charles, of Cowdenknowes, Earlston
1876 Hunter, Jas., of Antonshill, Coldstream
1892 Inglis, Alex., Greenlawdean, Greenlaw—*Free Life Member*
1857 Johnston, James, Huntingdon, Lauder
1893 Johnstone, Robert Fender, Northfield, Coldingham
1886 Laurie, John H., Hardens, Duns
1884 Leadbetter, H. M., Legerwood, Earlston
1859 Lockie, William, Choicelee, Duns
1884 Logan, Adam S., Ferney Castle, Reston
1876 Logan, J. W., M.I.Mech.E., Berwick
1893 Logan, Robert, Birkenside, Earlston
1893 Lyall, Alex., Greenknowe, Gordon
1863 Macbraire, J., of Broadmeadows, Berwick
1891 M'Donald, Dan., Hawkshaw, Coldstream
1868 M'Dougal, George, Blythe, Lauder
1893 M'Dougal, Jas., Eccles Tofts, Greenlaw
1893 M'Dougal, John, Lylestone, Lauder
1893 Mackay, John, Wyndhead, Lauder
1885 M'Lean, David, Estate Office, The Crooks, Coldstream
1881 Mack, Joseph, Berrybank, Reston
1870 Menzies, John, Bankhead, Duns
1892 Menzies, John C., Bankhead, Duns—*Free Life Member*
1894 Michael, Reginald Warburton, Crosbie, Earlston
1884 Middleton, Hilton, Kimmerghame Mains, Duns
1889 Millican, Gilbert T., Harelaw, Chirnside
1872 Muirhead, Frank, Paxton, Berwick
1893 Murray, James, Brockholes, Grant's House
1893 Murray, Thomas, Brockholes, Grant's House

Admitted
1880 Nisbet, George, Rumbleton, Greenlaw
1870 Nisbet, Jas., of Lambden, Greenlaw
1877 Paterson, George, Press Mains, Reston
1872 Paterson, James, Kidshielhaugh, Duns
1880 Porteous, James, Solicitor, Coldstream
1872 Rae, Robt., Burnbank, Foulden, Berwick
1878†Reay, The Right Hon. Lord, Carolside, Earlston
1893 Robertson, James Crawfurd, West Mains, Coldstream
1892 Robertson, William, Blinkbonny, Earlston—*Free Life Member*
1872 Robeson, George, Springwells, Greenlaw
1863 Romanes, Robert, of Harryburn, Lauder
1872 Rutherford, A., Rumbleton Law, Gordon
1863 Scott, T., of Mersington, Greenlaw
1890 Scott, Thomas, Abbey St Bathans, Grant's House
1872 Shiel, Andrew, Coldstream
1861 Simson, George, Courthill, Kelso
1863 Smith, Alex., Letham, Berwick
1890 Smith, Andrew, of Whitchester, Duns
1864 Smith, F. C., Hoprig, Cockburnspath
1872 Smith, J. F., Darnchester, Coldstream
1880 Somervail, J. A., Broomdykes, Chirnside
1891 Spence, Arthur Geo., Whitelaw, Edrom
1874 Stephenson, Richard, Chapel, Duns
1884 Swan, Robert G., Duns
1880 Swinton, J. L. Campbell, of Kimmerghame, Duns
1855 Thomson, James, Mungoswalls, Duns
1863 Torrance, George, Leetside, Chirnside
1863 Torrance, T., Whitsome Laws, Edrom
1894 Turnbull, George Gillon, Abbey St Bathans, Grant's House
1884 Tweedie, David, Nether Howden, Lauder
1894 Watson, J. M., Marygold, Edrom
1877 Weatherhead, Wm., Preston, Duns
1863 Weddell, John Wilkie, Lauder Barns, Lauder
1885 Welsh, Alex., Seedsman, Coldstream
1863 White, A., Kelloe Mains, Edrom
1880 White, E. C., Ayton Law, Ayton
1872 Wight, R. B., Ecclaw, Cockburnspath
1889 Wilkie, Jas. Bruce, of Foulden, Berwick
1862 Wilson, J., Chapelhill, Cockburnspath
1857 Wilson, Philip, Corn Factor, Duns
1864 Wood, James, Bigham, Coldstream
1874 Wyllie, James, Pathhead, Cockburnspath

## PEEBLES.

1873 Anderson, John, Cramalt, Selkirk
1884 Ballantyne, Wm., Wormiston, Eddleston
1882 Beresford, J. G. M., of Macbiehill, Lamancha
1877 Black, Wm. Connel, of Kailzie, Peebles
1872 Brown, Wm., Elderscroft, Springhill, Peebles
1884 Cairns, John, Winkston, Peebles
1881 Carmichael, G. H. G., Castle Craig, Dolphinton
1881 Carmichael, Sir T. D. Gibson, of Skirling, Bart., Castle Craig
1892 Constable, George W., Traquair Estate Office, Innerleithen
1874 Dickson, W. L., Drumelzier Haugh, Biggar
1884 Dyson, F. W., Crossburn, Peebles
1874 Elibank, Right Hon. Lord, Minden, Eddleston
1884 Ellis, John, Waterhead, Eddleston
1887 Erskine, Rear-Admiral James E., of Venlaw, Peebles
1882 Fergusson, Sir James R., of Spitalhaugh, Bart., West Linton
1880 Forrest, George, Edston, Peebles
1884 Forrest, T. M. Edston, Peebles

Admitted
1876 Gordon, Charles, of Hallmyre, Lamancha
1884 Gracie, Charles A., Easter Happrew, Stobo
1882 Greenshields, Dav., Garvald, Dolphinton
1880 Harper, J., Traquair Mains, Innerleithen
1882 Hay, Sir John Adam, of Haystoun, Bart., Kingsmeadows, Peebles
1892 Herdman, Geo., The Glen, Innerleithen
1894 Jack, Geo., Callands, Mountaincross, Peeblesshire
1869†Mackenzie, C. J., of Portmore, Eshiels, Peebles
1893 Macpherson, Donald, Elderston, Peebles
1885 Maxwell, James, Stobo Estate Office, Stobo
1843 Montgomery, Sir G. Graham, of Stanhope, Bart., Stobo Castle, Stobo—*Honorary Secretary of the Society*
1846 Montgomery, John B. H., Stobo Castle, Stobo
1852 Muir, G. W., Kirkhouse, Traquair
1884 Murray, W. J., Juniper Bank, Walkerburn
1889 Newbigging, Thomas, Corstane, Biggar
1882 Paterson, J., South Dawyck Mill, Stobo, Peebles
1881 Ritchie, G. D., Cloverhill, Biggar
1885 Slater, Andrew, Haystoun, Peebles
1880 Stodart, Thomas Tweedie, of Oliver, Broughton
1853 Tennant, Sir Chas., of The Glen, Bart., Innerleithen
1890 Tennant, Edward P., yr. of The Glen, Innerleithen
1877 Thom, Alex., Chapelhill, Peebles
1886 Thorburn, M. G., of Glenormiston, Innerleithen
1889 Thorburn, William, Craigerne, Peebles
1873 Tweedie, A. G., Hearthstone, Broughton, Peebles
1860 Tweedie, James, of Quarter, Biggar
1878 Williamson, Miss Katharine Isabella, of Cardrona, Peebles
1859 Wilson, J. F., Newton Villa, Peebles
1881 Wilson, James, Burnetland, Biggar
1884 Wilson, James, West Mains, Dolphinton
1860 Woddrop, W. A., of Garvald, Dolphinton

## ROXBURGH.

1872 Alexander, George, Easter Lilliesleaf, St Boswells
1884 Ballantyne, David, Shaws, Newcastleton
1860 Ballingall, George, Clarilaw, St Boswells
1863 Balmer, Thomas, Melrose
1863 Barrie, James, Harden Mains, Jedburgh
1886 Beattie, John, Braidlie, Newcastleton
1867 Bell, Alex., Yetholm, Kelso
1885 Bell, Wm. Scott, yr. of Woll, Hawick
1859 Borthwick, A. H., Ladiesyde Lodge, Melrose
1889 Boyd, Andrew, F.R.C.V.S., Melrose
1861 Boyd, John B., of Cherrytrees, Kelso
1863 Boyd, W. B., of Faldonside, Melrose
1880 Brown, J., Hundalee, Jedburgh
1884 Brown, James, Land Steward, Floors, Kelso
1866 Brunton, James, Broomlands, Kelso
1862 Brydon, Adam, Mounthooly, Jedburgh
1863 Burn, John, Newhouse, Yetholm
1872 Calder, Adam, Halterburn, Kelso
1876 Carre, T. A. R., of Cavers-carre, St Boswells
1871 Caverhill, John, Jedneuk, Jedburgh
1867 Charlton, M., jun., Browndeanlaws, Jedburgh
1893 Clark, John Gay, Mossburnford, Jedburgh

Admitted
1854 Clay, John, Kerchesters, Kelso
1880 Cochrane, A. L., of Kingsknowes, Galashiels
1872 Croall, John, Coach Works, Kelso
1872 Cunningham, C. J., of Muirhouselaw, Wooden, Kelso
1884 Cunningham, Robt., Glendouglas, Jedburgh
1889 Curle, Alexander, of Priorwood, Melrose
1888†Dalkeith, The Earl of, Eildon Hall, St Boswells
1865 Dalrymple, Hon. G. Gray, Elliston House, St Boswells
1889 Davidson, Alexander, Auctioneer, Melrose
1879 Davidson, Gilbert, Banker, Hawick
1872 Davidson, Wm., Colmslie, Galashiels
1890 Davidson, Wm., Cattle-salesman, Jedburgh
1854 Dickson, A., of Hassendeanburn, Hawick
1863 Dodd, James, Hundalee Cottage, Jedburgh
1863 Dodd, Nicholas, Nisbet, Jedburgh
1893 Douglas, Captain Edward Palmer, of Cavers, Hawick
1889 Douglas, Francis, Springwood Park, Kelso
1871 Douglas, George, Upper Hindhope, Jedburgh
1867 Douglas, George Sholto, 5 Abbotsford Grove, Kelso
18[illegible]†Dudgeon, J. Scott, Longnewton, St Boswells
1876 Dunn, John, Ramsay Lodge, Kelso
1880 Elliot, James, Burnhead, Hawick
1893 Elliot, John, Hindhope, Jedburgh
1863 Elliot, John, The Flat, Newcastleton
1874 Elliot, Robert Henry, of Clifton Park, Kelso
1893 Elliot, Thomas, Attonburn, Kelso
1893 Elliot, Thomas Robert Barnewall, yr. of Clifton Park, Kelso
1872 Elliot, Wm. B., of Benrig, St Boswells
1878 Erskine, Charles, Melrose
1884 Fairbairn, J. J., Greenend, St Boswells
1889 Fairfax, Rear-Admiral Henry, C.B., of Old Melrose
1884 Fleming, John, Roan, Newcastleton
1872 Forsyth, James (Hooper & Co.), Kelso
1893 Forsyth, Robert, New Smailholm, Kelso
1855 Gardner, Robert, Gattonside, Melrose
1843 Gibson, Thomas, Haymount, Kelso
1884 Grierson, Robert, Whitechesters, Hawick
1878 Grieve, C. J., Branxholm Park, Hawick
1890 Griffith, Sir Richard Waldie, of Hendersyde Park, Bart., Kelso
1895 Haddon, Andrew, Honeyburn, Hawick
1880 Haddon, Walter, Solicitor, Hawick
1893 Hall, William P., Hassendean Bank, Hawick
1889 Halliburton, J. H., Jed Bank, Jedburgh
1880 Hamilton, George, Abbey Hotel, Melrose
1892 Hay, Athole S., of Marlfield, Roxburgh
1880 Henderson, James, Estate Manager, Old Melrose, Melrose
1893 Henderson, J. Graham, Weensworth Mill, Hawick
1863 Hilson, George, Solicitor, Jedburgh
1862 Hobkirk, James, Broadhaugh, Hawick
1895 Hogarth, William Gray, Linton, Bankhead, Kelso
1889 Hutton, John, V.S., Kelso
1887 Johnston, John S., Crailinghall, Jedburgh
1889 Johnston, Wm. Lee, Oxnam Neuk, Jedburgh
1890 Karr, H. Seton, of Kippielaw, St Boswells
1893 Kennedy, Daniel, Littledeanlees, Jedburgh

Admitted
1883 Kerr, W. S., of Chatto, Sunlaws, Kelso
1890 Kidd, Henry, Lowood, Melrose
1863 Laing, George, Tweedbank, Kelso
1880 Laing, Thomas (Laing & Mather), Kelso
1880 Laing, Walter, Kersheugh, Jedburgh
1872 Lawrie, Thomas, Ormiston Road, Melrose
1863 Lees, Richard, Drinkstone, Hawick
1893 Logan, Somner, Harrietfield, Kelso
1869*†Lothian, The Marquis of, K.T., Monteviot, Jedburgh
1883 Macpherson, Donald, Wolfelee, Hawick
1893 Madder, James William, Taughill, Bowden, Mertoun, St Boswells
1893 Mather, R. V. (Laing & Mather), Kelso
1880 Maxwell, John, Coachbuilder, Kelso
1892 Mein, James A. W., Hunthill, Jedburgh
1893 Minto, the Earl of, Minto House, Hawick
1886 Moffat, James, Craik, Hawick
1863 Murray, John, of Wooplaw, Galashiels
1889 Noble, Robert, of Borthwickbrae, Hawick
1860 Ogilvie, George, Holefield, Kelso
1886 Oliver, Andrew R., Thornwood, Hawick
1889 Oliver, Geo. Lindsay, Whithaugh, Newcastleton
1852 Oliver, James, of Thornwood, Hawick
1880 Oliver, John, Borthaugh, Hawick
1853 Oliver, Robert, of Blakelaw, Lochside, Kelso
1893 Oliver, Captain William James, Hoselaw, Kelso
1878 Oliver, Wm. M., Howpasley, Hawick
1893 Paton, E. D., Sintonparkhead, Hawick
1889 Paton, Major James, of Crailing, Jedburgh
1893 Peter, John Stewart, Lintalee, Jedburgh
1863*†Polwarth, Right Hon. Lord, Mertoun, St Boswells
1889 Polwarth, The Hon. The Master of, Mertoun, St Boswells (Humbie House, Upper Keith)
1854 Pott, Gideon, of Dod, Knowesouth, Jedburgh
1856 Rawdin, Joseph, Chemist, Jedburgh
1863 Rea, Charles, Cleithaugh, Jedburgh
1872 Renwick, John, Nurseryman, Melrose
1894 Ritchie, D. N., of The Holmes, St Boswells
1889 Robertson, John, Borthwickbrae, Hawick
1863 Roberton, John, Falside, Stitchill, Kelso
1893 Roberton, James, Ladyrigg, Kelso
1863 Roberton, Robert, Ladyrigg, Kelso
1880 Rodger, James, Minto Estate Office, Hawick
1880 Ross, Richard, Rutherford, Kelso
1893 Routledge, Richard, Gorrenberry, Newcastleton
1884 Rutherfurd, W. E. Oliver, of Edgerston, Jedburgh
1880 Scott, The Hon. H. J., Brotherston, St Boswells
1888 Scott, Hon. J. C. Maxwell, of Abbotsford, Melrose
1884 Scott, Chas., Milsington, Hawick
1863 Scott, George, Kersknowe, Kelso
1882 Scott, H. J. E., of Makerston, Kelso (Weston, Underwood, Derby)
1894 Scott, John, Newton, Hawick
1881 Scott, John Corse, of Synton, Hawick
1889 Scott, John Robson, yr. of Newton, Jedburgh
1863 Scott, Robert, Falnash, Hawick
1863 Scott, T., of Mersington, Leitholm, Coldstream
1863 Scott, Sir W., of Ancrum, Bart., Jedburgh
1894 Shepherd, David, Hardies Mill Place, Kelso
1883 Sinclair, C. G., Grahamslaw, Kelso

Admitted
1879 Smith, James, Kelso
1893 Smith, James, of Olivebank, St Boswells
1880 Smith, John, Galalaw, Kelso
1888 Smith, J. R. C., Mowhaugh, Kelso—*Free Life Member*
1881 Smith, R. C., Ormiston, Jedburgh
1887 Smith, Thomas A., Kirkton, Hawick
1888 Sprot, Edward William, of Drygrange, Melrose
1887 Sprot, Lieut.-General John, of Riddell, Lilliesleaf
1872 Stavert, Archd., of Hoscote, Hawick
1851 Stedman, James, Timpendean, Jedburgh
1880 Storie, W. G. R., Newtown, Jedburgh
1846 Tait, James, Banker, Kelso
1893 Taylor, William, Ashybank, Hawick
1867 Thomson, A., of Mainhill, St Boswells
1868 Thomson, Geo., Hopton, Ancrum, Jedburgh
1889 Thomson, William, Whitelee, St Boswells
1863 Turnbull, J., Eastfield, Kelso
1889 Turnbull, Mark, Melrose
1863 Turnbull, W. Geo., Spittal, Jedburgh
1863 Turnbull, Wm. J., Beaumont Cottage, Sprouston
1853 Usher, John, Kelso
1872 Usher, Thomas, Courthill, Hawick
1880 Waddell, Alex., of Palace, Jedburgh
1893 Watson, Robt. F., Briery Yards, Hawick
1889 Watson, T. Lindsay, Seaburn, Hawick
1886 Watson, Capt. W. S., of Burnhead, Hawick (care of T. Usher, Courthill, Hawick)
1890 White, Alex Nottylees, Kelso
1863 Wilson, George, Kilmeny, Hawick
1895 Winter, Ramsay, Ruthven, Coldstream

## SELKIRK.

1866 Anderson, B. T. G., of Tushielaw, Selkirk
1863 Anderson, G., of Hawthorn Bank, Selkirk
1889 Anderson, S. Scott, of Shaws, Selkirk
1863 Brown, Adam, Hyndhope, Selkirk

Admitted
1889 Bruce, John, Easter Langlea, Galashiels.
1867 Brunton, J. S., Ladhope, Galashiels
1893 Cochrane, Walter, Leynaliurst, Galashiels
1889 Connochie, Thomas D., V.S., Galashiels
1877 Connochie, William Dixon, V.S., Selkirk
1877 Dennistoun, J. W., of Dennistoun, Harewood Glen, Selkirk
1871 Dun, John, Galashiels
1869 Elliot, A. T., Newhall, Galashiels
1889 Elliot, John, Meigle, Galashiels
1854 Elliot, Thomas, Blackhaugh, Galashiels
1860 Elliot, Walter, Hollybush, Galashiels
1889 Gibson, Thomas, jun., Torwoodlee, Galashiels
1878 Grieve, James, Howden, Selkirk
1885 Grieve, James, jun., Fernielee, Selkirk
1875 Howatson, J. L., Ramsaycleugh, Selkirk
1878 Laidlaw, Robert, Rodono, Selkirk
1889 Laidlaw, Thomas R., Langshaw, Galashiels
1849 Lang, Hugh M., of Broadmeadows, Selkirk
1878 Lang, Robert J., Broadmeadows, Selkirk
1889 Lawrence, David, Whytbank, Galashiels
1878 Lindsay, John V., Whitehope, Selkirk
1873 Linton, Simon, Oakwood, Selkirk
1888 Macfarlane, Jas., Ashiestiel, Galashiels
1880 Mitchell, Thomas, Howford, Selkirk
1880 Muir, John, Dryhope, Yarrow, Selkirk
1843†Napier and Ettrick, Right Hon. Lord, K.T., Thirlestane Castle, Selkirk
1885 Plummer, Chas. H. S., of Sunderland Hall, Selkirk
1868 Potts, Andrew, Beechwood, Selkirk
1859 Pringle, Alex., of Whytbank, Selkirk
1863 Pringle, J. T., of Torwoodlee, Galashiels
1893 Purdon, Finlay, Fushielaw, Selkirk
1880 Riddell, John, Rink, Galashiels
1893 Roberts, George, Whitelee, Galashiels
1889 Scott, Alex., Ladhope, Selkirk
1880 Scott, John, of Gala, Galashiels
1880 Turnbull, James, Fauldshope, Selkirk
1893 White, S., Caddonlee, Galashiels

# ENGLAND.

Admitted
1855 Alexander, John, 9 Raymond Terrace, Cheltenham
1878 Ancaster, The Earl of, Normanton Park, Stamford
1873 Anderson, J., Bradbury, Enville, Stourbridge
1850 Anderson, Robert Hood, Devonshire Club, London
1893 Anderton, Geo. Herbert, Kelpin Lodge, Howden, Yorks
1868 Angus, John, Whitefield, Morpeth
1864 Archer, Thomas, 1 Westminster Chambers, Victoria Street, London
1861 Archibald, James, Brinklow, Coventry
1873 Ashdown, A. H., Uppington, Wellington, Salop—*Free Life Member*
1858 Askew, Wilson, of Pallinsburn, Coldstream
1883 Aveling, T. L., Rochester
1890 Bamford, Henry, jun., Leighton Iron Works, Uttoxeter
1880 Barrett, Robert Bell, Skipton Castle, Skipton
1872 Bell, And., Hilgay, Downham Market, Norfolk
1869 Bell, Robert, 5 Latimer Street, Tynemouth
1877 Bell, T. (Messrs Robey & Co.), Lincoln
1884 Benson, R. A., Duchy of Cornwall Office, Liskeard, Cornwall—*Free Life Member*
1882 Bigg, Thomas, Great Dover Street, London
1885 Birch, W. de Hoghton, Hoghton Estate Office, Walton Hall, Preston—*Free Life Member*
1874 Bird, Ebenezer, Ramornie, Kington, Herefordshire
1865 Black, Major Alexander, 21 Lanhill Road, London, W.
1859 Black, John, Ford, Northumberland
1888 Blackett, J. S., Bongate Hall, Appleby, Westmoreland
1887 Blackie, Alfred, 77 Palace Road, Norwood, London
1893 Blackstone, Edward Christopher (Blackstone & Co., Limited), Stamford
1875 Blackwood, Alex., Estate Office, Leadenham, Lincoln
1863 Bolam, John, Bilton, Lesbury, Northumberland
1879 Bonnor, G. H., 14 Cockspur Street, Pall Mall, London, S.E.
1864 Borton, John, Barton House, Malton
1875 Brotchie, G., Grinkle, Loftus, R.S.O.
1877 Brown, John, Morden Farm, Hertford
1873 Browne, Colvile, 26 Mill Street, Bedford —*Free Life Member*
1868 Bruce, Robert, Elm Grove, Darlington
1884 Brydon, John, Seed Merchant, Darlington
1873 Brydon, Robert, The Dene, Seaham Harbour—*Free Life Member*
1835 Buccleuch and Queensberry, The Duchess-Dowager of, Boughton House, Kettering
1875 Bullock, Matt., 48 Prince's Gate, London, S.W.
1870 Burdett-Coutts, Baroness, 1 Stratton Street, Piccadilly, London
1877 Burr, John M., Writtle Park, Ardinstor, Essex
1894 Burrell, Charles, jun., Thetford, Norfolk
1882 Burton, Dr M. B., Oswell House, Lindley, Huddersfield
1870 Cairns, John, Fernbank, Heaton Chapel, Stockport
1878 Cameron, H. E., Newton Leys, Ashbourne, Derbyshire
1868 Campbell, A. H., Cornwall Gardens, London, S.W.
1863 Campbell, G. W., 22 Queen's Gate, London, S.W.
1838 Campbell, Sir James, Bart., Wheatmead Park, Lydney
1894 Carlisle, Countess of, Naworth, Brampton, Cumberland
1880 Carnegie, Wm. C., Sarsden, Chipping Norton
1878 Carr, Robt., Felkington, Norham, Berwick-on-Tweed—*Free Life Member*
1887 Carrington, George, M.R.A.C., Missenden Abbey, Great Missenden, Bucks —*Free Life Member*
1838 Carstairs, D., Hailes House, Fairfield, Liverpool
1877†Cecil, Lord Arthur, Orchardmains, Tunbridge
1877 Cecil, Lord Lionel, Orchardmains, Tunbridge
1884 Chambers, T. W., Prospect House, Pelutho, Abbeytown
1894 Clark, Geo., Dovenby Hall, Estate Office, Cockermouth
1877 Clark, James, Somerby, Grantham
1884 Clark, J. M., Featherstone Castle, Haltwhistle
1873 Clark, William, New Mouson, Belford
1893 Clarke, Thomas, Rudchester, Wylam-on-Tyne
1877 Clench, F. (Messrs Robey & Co.), Lincoln
1884 Clinton, W. E. Pelham, Moore Court, Stroud—*Free Life Member*
1890 Colquhoun, William E. Campbell, yr. of Killermont, Chesterton Lodge, Harbury, Leamington
1857 Collyer, W. D., Craig Nethan, Weston-super-Mare
1851 Colville of Culross, Right Hon. Lord, K.T., 41 Eaton Place, London
1877 Corbett, T., Perseverance Iron Works, Shrewsbury
1891 Coward, T. A., Eden Town, Carlisle—*Free Life Member*
1879 Crabb, Wm., Silloth, Cumberland
1890 Crabtree, Henry, 50 William Street, Heywood, Lancashire—*Free Life Member*
1890 Craig, James, The Blanks, Newdigate, Surrey

Admitted
1880 Craig, James, 25 The Avenue, Bruce Grove, Tottenham, London.
1882 Craig, Robert, Crondon Park, Billerican, Essex
1860 Crawford, Daniel, Pottorells Farm, Hatfield, Herts
1893 Crow, Philip Mansfield, Howden, Yorks
1868 Cruikshank, Edward C., Shrublands, Graffham, Petworth, Sussex
1876 Cruickshank, J. W., Coombe Head, Haslemere, Surrey
1894 Daine, Herbert S., Harris Institute, Preston—*Free Life Member*
1874 Dallas, A. G., 10 Tervor Terrace, London, S.W.
1894 Davidson, William, Tithe Hill, Cornhill-on-Tweed
1887 Davies, Edward Smith, Atchley, near Shifnal—*Free Life Member*
1859 Dawson, J., Lymore, Montgomery, N. Wales
1894 De la Mothe, Joseph, Agricultural College, Aspatria—*Free Life Member*
1869 Dickie, Joseph, The Bank House, The Broadway, Tooting, London, S.W.
1886 Dickson, Thos. A., Estate Office, Overstone Park, Northampton—*Free Life Member*
1894 Dixon, T., jun., Leadhill, Stocksfield-on-Tyne
1849 Dixon, Thomas G., Dolbon, St Asaph
1880 Dollar, T. A., V.S., 56 New Bond Street, London
1887 Don, H. G., The Lodge, Fingringhoe, Colchester
1871 Donne, Henry, Leek Wootton, Warwick
1872 Douglas, Thomas, 5 Charlotte Square, Newcastle
1885 Douglas, Wm., Dalveen, Malcolm Road, Wimbledon, Surrey
1861 DRUMMOND, Hon. F., 58 St George's Square, London
1874 Duff, G. Smyttan, 58 Queen's Gate, South Kensington, London, S.W.
1879 Duncan, John, Tilney, St Lawrence, Kings Lynn
1882 Duncan, John W., Coldrey, Bentley, Farnham, Surrey
1882 Duncan, Robert, Berwick Farm, Stamford River, Essex
1871 Eden, Henley, Woodstock, Ascot, Berks
1878 Edmondson, T., 144 Princes Street, Old Garralt, Manchester
1895 Egginton, Arthur, South Ella, Hull
1873 Eley, Rev. Dr Wm. H., Etchingham Rectory, Hawkhurst—*Free Life Member*
1875 ELLESMERE, The Right Hon. The Earl of, Worsley Hall, Manchester
1873 Elliot, Prof. Thos. J., Hole Park, Rolvenden, Kent—*Free Life Member*
1880 Ellis, O. W., 6 Grosvenor Place, Jesmond, Newcastle-on-Tyne
1882 Ensor, Thos. H., 54 South Street, Dorchester—*Free Life Member*
1882 Esson, Robert, 42 Duke Street, St James's, London, W.
1886 Faber, Alfred D., Belmont, Ilfracombe—*Free Life Member*
1869 Ferme, G., Leigham Lodge, Roupell Park, Streatham Hill, Surrey
1894 Fielding, J. B., Downing, Holywell, North Wales
1891 Fleet, W. J., Estate Office, Thurlow, Suffolk—*Free Life Member*
1876 Fleming, D. G. Pavarham, Bedford
1881 Fleming, Hugh Felmersham, Bedford
1891 Forbes, A. C., the Home Farm, Bowood, Calne, Wilts—*Free Life Member*
1856 Forbes, C. W. Sandecotes, Parkstone, Dorset

Admitted
1894 Forrester, James John, Bryanston, Blandford, Dorset—*Free Life Member*
1854 Friar, Thomas, of Grindon Ridge, Norham-on-Tweed
1892 Gascoigne, Major R. F. T., Lotherton Hall, Aberford, Leeds
1877 Gell, H. C. Pole, Hopton Hall, Wirksworth
1879 Gibson, J. G., 1 Vanburgh Park, Blackheath, London
1889 Gilchrist, D. A., University Extension College, Reading—*Free Life Member*
1882 Gilkes, Gilbert, Canal Iron Works, Kendal
1873 Goddard, H. R., Fairfield, Illogan, Redruth—*Free Life Member*
1875 Gordon, W. R. G., Barsham Lodge, Sandown, Isle of Wight
1866 Gough, Wm., Land Agent, Wykeham
1881 Gover, L. D., 30 Bernard Street, Russell Square, London, W.S.—*Free Life Member*
1886 Gow, George, Tregothnan Office, Truro
1865 Graham, Paul, Brooks's Club, London
1873 Graham, Robert G., Beanslands Park, Irthington, *viâ* Crosby-on-Eden, Carlisle
1888 Graham, William, Eden Grove, Kirkbythore, Penrith
1862 GRANT, Field-Marshal Sir Patrick, G.C.B., Chelsea Hospital
1858 Gray, T. R., St Margaret's, Cheltenham
1892 Griffen, Hugh Reid (W. A. Wood & Co.), 36 Worship Street, London
1834 Gwynne, A. T. J., of Monachty, Cardigan
1884 Hall, David, Ingram, Alnwick
1877 Hall, T. F., Billiter Buildings, Billiter Street, London, E.C.
1883 Hamilton, H. W., Lilleshall, Newport, Salop—*Free Life Member*
1888 Handley, John, Greenhead, Milnthorpe
1887 Handley, William, Greenhead, Milnthorpe, Westmoreland
1884 Hardy, C. W. L., Gittisham, Honiton—*Free Life Member*
1867 Harris, Wm., 16 The Grove, Blackheath, London, S.E.
1875 Haughton, W. H., Highlands, Gt. Burford, St Neots
1887 Haviland, W. A., Warbleton, Heathfield, Sussex
1883 Hayward, C. P., Beaumont Manor, Lincoln
1878 Henderson, John, Estate Office, West Dean, Chichester—*Free Life Member*
1854 Henderson, Thos., Hastings Cottage, Seaton Delaval, Newcastle-on-Tyne
1881 Henderson, W., East Eltington, Hexham—*Free Life Member*
1877 Herdman, George, The Abbey Farm, Massingham
1883 Hetherington, R. B., Earl Street, Carlisle
1873 Hill, A. J., 36 Lansdowne Road, London, W.—*Free Life Member*
1894 Hill, Henry F., Agricultural College, Aspatria—*Free Life Member*
1873 Holliday, Jonathan, Kirkbampton, Carlisle
1878 Holliday, Wm., Pelutho West House, Abbey Town, Carlisle
1878 Holliday, Wm., Plumbland, Aspatria, Carlisle
1882 Holm, Alex.
1875 Holm, John, Waterend, Ongar, Essex
1886 Hooper, C. H., Highlands Farm, Swanley, Kent—*Free Life Member*
1880 Hope, A., Cleveland Cottage, Middleton in Teesdale

Admitted
1878 Hope, John W., 3 Rumford Street, Liverpool
1878 Hornsby, J., Spittalgate Ironworks, Grantham
1863 Howie, H. B., North Hazelrigg, Belford
1865 Hudspith, Wm., Green Croft, Haltwhistle
1860 Hume, Archibald, 14 Imperial Square, Cheltenham
1870 Hunt, A. E. Brooke, Holmsley, Slough, Bucks—*Free Life Member*
1868 Hutton, Arthur, Lorton, Tottenhall, Cheshire
1888 Inman, A. H., care of Glyn, Mills, Currie, & Co., 67 Lombard Street, London, E.C.—*Free Life Member*
1895 Irving, John, Mossband, Rockliffe, Carlisle
1893 Irwin, Major T. A., Lynehow, Carlisle
1893 Jones, C. B., University College of North Wales, Bangor—*Free Life Member*
1873 Juckes, R. F., Harley, Much Wenlock—*Free Life Member*
1894 Keay, J. Seymour, M.P., 44 Bassett Road, North Kensington, London, W.
1876 Keith, Lieut.-Col. Jas., Capel Hall, Frimley, Ipswich
1875 Kennedy, W., Lewes and County Club, Lewes—*Free Life Member*
1883 Kenyon, J. W., Oxly Woodhouse, Fartown, Huddersfield
1874 Kidd, H., V.S., Burton Street, Melton Mowbray
1862 Kilpatrick, P., 32 Old Kent Road, London
1893 Konger, Alf. Eugene, Goodrington House, Paignton, South Devon
1894 Laidlaw, Percy O., 1 Portland Terrace, Newcastle-on-Tyne
1874 Laing, Wm., Dunholme Lodge, Nettleham, Lincoln
1868 Lawes, Sir John B., Bart., Rothamstead, St Albans
1878 Leggat, Alex., 248 Dixon Road, Wavertree, Liverpool
1875 Lightfoot, H. Le Blanc, Corpus Christi College, Oxford
1891 Lister, Joseph, Little Broughton, Carlisle—*Free Life Member*
1865 Lockhart, Peter, Land Agent, Edenhall, Penrith
1885 Londonderry, Most Noble The Marquis of, Seahamhall, Seaham Harbour
1881 Lonsdale, Claud, Rose Hill, Carlisle
1885 Lopes, Sir Massey, Bart., 28 Grosvenor Gardens, London
1843 Lorimer, T. W., Hyde Cottage, Torr Street, Buxton, Derbyshire
1850 Lowndes, Major Jas., Junior United Service Club, London
1884 Lyal, William, Myton Grange, Helperby, York
1885 M'Callum, Col. Kellie, Naval and Military Club, Pall Mall, London
1878 M'Connell, P., Ongar Park Farm, Ongar —*Free Life Member*
1878 M'Cracken, W., Crewe—*Free Life Member*
1880 M'Creath, H. G., Galagate House, Norham-on-Tweed
1888 Macdonald, Alex., Proprietor, '*Farmer and Stockbreeder*, 190 Fleet Street, London, E.C.
1841 Macdonald, Major-Gen. Alister M'Ian, 27A Park Lane, London, W.
1891 Macdonald, Charles, Editor, *Farmer and Stockbreeder*, 190 Fleet Street, London, E.C.
1877 M'Fadyean, Prof. J., Royal Veterinary College, Camden Town, London
1879 M'Gregor, Alex., Leigh, Lancashire

Admitted
1865 Macgregor, Thos., The Chestnuts, Brandenburgh Road, Sunnerbury, W.
1882 Mackay, John, 31 Beresford Road, Birkenhead
1875 Mackay, Thomas, Westwood, Coventry
1882 M'Kerrell, R. M., Junior Carlton Club, Pall Mall, London
1874 M'Kerrow, A., Brecon Farm, Shelf, Halifax, Yorks
1846 Mackintosh, G. G., Richmond House, Twickenham
1880 M'Laren, John, Hunslet, Leeds
1846 Macleay, Alex. D., Conservative Club, London, W.
1865 M'Lennan, Donald, 42 Sackville Street, Piccadilly, London, W.
1883 M'Leod, J. M., 2 Hilldrop Road, Camden Road, London, N.
1886 M'Minnies, Henry H., Farington, Preston—*Free Life Member*
1870 M'Monies, J., Chevening Estate Office, Sevenoaks, Kent
1865 Macnaghten, Sir Steuart, Bitterne Manor House, Southampton
1870 M'Naughton, D., 79 Mark Lane, London, E.C.
1875 Maddison, H., The Lindens, Darlington
1870 Main, G. Agnew, Portland Square, Carlisle
1884 Malcolm, John, M.R.C.V.S., Birmingham—*Free Life Member*
1880 Mangin, W. Nangreave, Preston, Chathill
1861 Mangles, Geo., Givendale, Ripon, Yorkshire
1882 Mann, Robt. J., Home Farm, Acton Burnell, Shrewsbury
1884 Marriott, T. E., Newnham House, Daventry
1873 Marryat, George Selwyn, The Close, Salisbury
1868 Marshall, James, Gainsborough
1877 Martin, E., Wimbledon, London
1888 Massey, Fred. J., 54 Bunhill Row, London
1884 Maxwell, Hon. B. C., Walworth Castle, Darlington
1879 Meade-Waldo, E. W., Barmoor Castle, Beal
1894 Meiklejohn, D. W., Wyndyard Park, Stockton-on-Tees
1891 Menzies, Robert, Merton, Thetford
1877 Millican, J., Wedholm House, Abbey Town
1873 Mitchell, John, 6 Clarendon Square, Leamington Spa
1869 Moffat, James, White Lion, Brampton
1861 Montagu of Beaulieu, Lord, Palace House, Beaulieu, Southampton
1885 Moore, George, Blakemoor, Cresswell, Morpeth
1839 Moore, John C., Brook Farm, Cobham, Surrey
1878 Moubray, J. M., Broom Court, Alcester
1880 Moult, John, Royal Buildings, Newcastle-on-Tyne
1877 Mounsey, Wm. R. Lowther, Newton, Penrith
1888 Muir, James, Yorkshire College, Leeds—*Free Life Member*
1873 Munby, E. C., The Hermitage, Oswaldkirk—*Free Life Member*
1867 Murray, G., Elvaston Castle, Derby
1873 Murray, James, Junior Carlton Club, London
1865 Nepean, Sir M. H., of Loders Court, Bart., Bridport
1872 Newton, T. H. G., Barrels Park, Henley-in-Arden, Birmingham
1878 Nicholson, W. N., Newark

Admitted
1882 Nickels, John Tetley, The Day House, Shrewsbury
1893 Nimmo, Wm., Castle Eden, Co. Durham
1892 Noel, Ernest, Lydhurst, Haywards Heath, Sussex
1879 North, G. F., Strathfieldsaye, Mortimer, R.S.O., Berks
1853 Ogilvie, Wm. R., Ormside, Appleby, Westmoreland
1874 Ogilvy, John F., 21 The Grove, South Kensington, London
1872 Oliphant, L. J., Guards' Club, London
1875 Ord, J. R., Haughton Hall, Darlington
1894 Parkin-Moore, Wm., Whitehall, Mealsgate, Carlisle
1867 Paterson, C., Canford Manor, Wimborne
1857 Paton, A., Norwood, Sydenham, London
1869 Pender, Sir John, 66 Old Broad Street, London
1888 Perkins, W. F., M.R.A.C., Portswood House, Southampton—*Free Life Member*
1889 Pilkington Claude M., Harewood, Leeds
1885 Pollock, Tho., Estate Office, Boduant, Eglwysbach, R.S.O., Denbighshire
1893 Powell, J. E., Cambrian Iron Works, Wrexham
1885 Prentice, Manning, Chemical Works, Stowmarket
1875 Preston, W. Conway, Stream, Farnham, Surrey
1883 Quibell, W. O., Highfield House, Newark
1892 Rand, John, South Benington, Beal
1878 Ransome, James Edward, The Orwell Works, Ipswich
1878 Reay, Thomas, Abbey Town, Carlisle
1857 Redfern, W. Macquarrie, Conservative Club, St James Street, London
1877 Rennie, John, Askham, Retford
1878 Richardson, R. A., 128 Shiel Road, Newsham Park, Liverpool
1888 Richmond, Jas. G., Globe Works, Southhall Street, Manchester
1880 Riddle, Andrew, Yeavering, Wooler
1852 Rintoul, Chas., Strawberry Hall, Buxted, Sussex
1886 Robertson, Charles T. A., Little Horringer Hall, Bury St Edmunds—*Free Life Member*, 1888
1876 Robertson, George, Athenæum Club, Pall Mall, London
1891 Robertson, S. S., L. & N.-Western Railway, Broad Street, London
1878 Robinson, Thos., Cargo, Carlisle
1884 Robson, Jacob, Byrness, Otterburn
1881 Rodger, Geo., Newton Bank, Preston Brook
1888 Rodger, R., Hadlow Castle, Tunbridge
1873 Rome, Thos., Charlton House, Charlton Kings—*Free Life Member*
1879 Roscoe, Wm. C., Ash House, Whitchurch, Salop
1870 Ross, J., The Grove, Ravenglass, Carnforth
1890 Rudd, Ash, East Ruston Hall, Stalham, Norwich—*Free Life Member*
1870 Ryrie, R., 34 Park St., Grosvenor Sq., London
1888 Scott, Adam, Fawdon, Glanton, Northumberland
1893 Scott, Robert, Wyndham Hotel, Bootle, Liverpool
1872 Selby, B. P., Paston, Coldstream
1890 Sessions, Harold, Russell House, Gloucester—*Free Life Member*
1863 Shand, Right Hon. Lord, 32 Bryanston Square, London, W.
1878 Sinclair, The Right Hon. Lord, 55 Onslow Square, London, S.W.
1873 Smith, Thos. K., 50 Greystone Road, Carlisle
1854 Smith, Wm., Melkington, Cornhill
1894 Smithson, Joseph S. (F. Farmer & Co., Ltd.), Billiter Buildings, Billiter St., London, E.C.
1892 Solomon, F. O., North-Eastern County School, Barnard Castle — *Free Life Member*
1881 Somerville, William, B.Sc., Durham College of Science, Newcastle-on-Tyne —*Free Life Member*, 1887
1893 Spencer, Sanders, Holywell Manor, St Ives, Hunts
1887 Stanhope, John Montague Spencer, Cannon Hall, Barnsley, Yorkshire
1869 Statter, T., jun., Stand Hall, Whitefield, Manchester
1884 Stephen, H. C., Avenue House, Finchley, London
1880 Stephenson, C., V.S., Sandyford Villa, Newcastle
1870 Steuart, D. K., 14 Binswood Avenue, Leamington Spa
1875 Stevenson, Alex. S., Oatlands Mere, Weybridge, Surrey
1858 Stewart, J. A. Shaw, 71 Eaton Place, London
1863 Stewart, Neil P., Vaynol, Bangor, North Wales
1877 Stirling, A., 30 Eccleston Street, London, S.W.
1884 Stordy, Norman, Thurstonfield Tannery, Carlisle
1865 Swanwick, R., R.A.C. Farm, Cirencester
1894 Tait, Richard E., Newbigging, Norham on Tweed
1888 Thompson, Henry, V.S., Aspatria
1883 Tiffen, J. H., 4 Grosvenor Terrace, Hull —*Free Life Member*
1869 Tinning, J., Lowther Street, Carlisle
1894 Tipper, Charles J. R., Agricultural College, Aspatria—*Free Life Member*
1889 Toppin, John C., Musgrave Hall, Skelton, Penrith
1891 Townley-Parker, T. Townley, Cuerdon Hall, Bamber Bridge, Preston
1866 Trotter, T. C., 54 Park Street, Grosvenor Square, London, W.
1859 Turner, Frederick J., Mansfield, Woodhouse, Mansfield, Notts
1889 Turner, Thos. Warner, Welbeck, Worksop, Notts
1878 Twentyman, J. M., Hawkrigg House, Wigton, Cumberland
1877 Unite, John, 201 Edgeware Road, London, W.
1877 Vane, Sir H. R., of Hutton in the Forest, Bart., Penrith
1872 Walker, J. P. S., Littlegate, Oxford
1873 Wall, George Y., Durham — *Free Life Member*
1873 Walton, G. K., Long Campton, Shipston-on-Stour—*Free Life Member*
1894 Ward, Martin H., Agricultural College, Aspatria—*Free Life Member*
1883 Wardman, Robert, Warwick Bank House, Carlisle
1880 Webb, Major W. G., of Woodfield, Wordsley, Stourbridge
1894 Wedderburn, Sir W., of Ballendean, Bart., M.P. for Banffshire, Meredith, Gloucester
1860 Welsh, John, Rudfen Manor, Kenilworth
1863 Wharncliffe, Right Hon. Lord, 15 Curzon Street, London
1891 White, W. E. C., c/o F. Punchard, Underley Estates Office, Kirkby, Lonsdale—*Free Life Member*

Admitted
1894 Whittaker, John D., Birch House, Lees, Oldham—*Free Life Member*
1888 Wilkie, Thomas, Forester to the London County Council, 21 Belleville Road, Wandsworth, London, S.W.
1854 Willis, T., Manor House, Carperby, Bedale
1859 WILSON, Sir Jacob, Chillingham Barns, Alnwick—*Free Life Member*, 1873
1892 Wilson, Jas., jun., University College of Wales, Aberystwyth—*Free Life Member*
1892 Wilson, William, Goodyhills, Maryport —*Free Life Member*
1873 Wilson, William, Leigh, Lancashire

Admitted
1878 Wilson, William, Low Barmiston, Washington Station, Durham
1858 Wilson, William, Borough, Sanderstead, Croydon, Surrey
1881 Woodroffe, D., Chace View, Rugeley
1876 Wordsworth, R. W., Whitemoor House, Ollerton, Notts
1879 Young, R. W., Billeswell Manor, Lutterworth
1878 Young, Wm., 81 Drummond Street, Euston Square, London, N.W.
1877 ZETLAND, Earl of, Aske, Richmond, Yorkshire

# IRELAND.

1860 Brodie, Jas. W., Cloheen, Buttevant, Co. Cork
1873 Campbell, Geo., Kilkea, Mageny, Co. Kildare—*Free Life Member*
1877 Fennessy, Thos., Grange Villa. Waterford
1838 Fox, Richard M., of Foxhall, Rathowen
1876 Gilchrist, And., Grovedale, Golden Ball, Co. Dublin
1884 Goulding, W. J., Fitzwilliam Sq., Dublin
1892 Kennedy, Samuel, Dundela, Strandtown, Belfast
1876 Maconchy, J. A., Kildare Street Club, Dublin—*Free Life Member*
1870 Paterson, Alex., Townnakeady, Ballinrobe, Mayo
1889 Purefoy, Edward B., Greenfields, Tipperary—*Free Life Member*
1883 Robertson, Thomas, Great Northern Railway, Amiens Street, Dublin
1871 Roy, Fred Lewis, Wellpark, Oughterard, Co. Galway

# FOREIGN COUNTRIES.

1880 Aalvik, E. A., Ostenso, Hardanger, Norway
1882 Alexander, A. S., 216 Clark St., Chicago —*Free Life Member*
1876 Anderson, R. Lang, Manager, The Aboukir Company, Limited, Ramleh, Egypt—*Free Life Member*
1864 Arbuthnott, Hon. Mrs, Norway
1881 Auld, R. C., Bishop Crescent, Chicago, U.S.A.
1868 Baird, Arthur E., Brussels
1887 Banerjee, N. N., Calcutta—*Free Life Member*
1883 Basu, G. C., 196 Bowbazar St., Calcutta —*Free Life Member*
1876 Bean, William, Rosebank, Winnipeg, Manitoba
1881 Blyth, A. H., Frankfield, Manitoba
1842 Booth, James G., Seed Merchant, Hamburg
1851 Bogie, John, Auckland, New Zealand
1878 Bramwell, John, River Plate Trust Loan and Agency Co., Calle San Martin 50, Buenos Ayres—*Free Life Member*
1876 Brown, J. H., Wairoa, New Zealand
1871 Bruce, George C., Staunton, Virginia, U.S.A
1879 Brydone, W. S., Dunedin, New Zealand
1874 Burn, Forbes, care of The National Agricultural Society of Victoria, Bourke Street, Melbourne—*Free Life Member*
1870 Cantlie, Charles A., Natal
1850 Christie, A., Glencairn, Dipton, Southland, New Zealand
1864 Coteswortb, Robert, Cannes, France
1868 Craig, R. (Francis Lowe & Co.), Chapelton, Jamaica
1875 Crerar, Donald, Estancia San Alonzo, Estacions Bavio, F.C. Ensenada, Buenos Ayres
1883 Croil, Thos., North Western Sledge Co., Millwaukie, Wisconsin, U.S.A.
1872 Currie, James J., Blinkbonny, Birtle, Manitoba
1877 Curror, Adam Henry, Studio, Sherman Block, St Paul's, Minnesota, U.S.A.
1876 Donaldson, Alexander, 54 Avenue Wagram, Paris
1888 Drieberg, Christopher, Colombo, Ceylon —*Free Life Member*
1894 Duff, J. K. Mackenzie, South Africa
1880 Dundas, T. G., 39 North State Street, Chicago
1855 French, J., Sortkjeer, Fredrickshaven, Denmark
1873 Giglioli, Italo, Professor of Agricultural Chemistry, Portici—*Free Life Member*
1870 Gordon, R. W., British Columbia (c/o John Gibson, Howford, Peebles)
1855 Graham, H., Auckland, New Zealand
1827 Graham, James, Toronto, Canada
1867 Hallen, J. H. B., M.R.C.V.S., Inspecting Veterinary Surgeon, Bombay
1863 Hardie, William H., Gamboola, Casterton, Victoria, Australia
1884 Harris, Richard H., Papatoitor, Auckland, New Zealand
1871 Heggie, Henry, Roseburg, Douglas Co., Oregon, U S.
1880 Hoggan, Andrew, jun., Queensland
1880 HOLMES, The Hon. Matthew, Cintra, Dunedin, New Zealand
1891 Irving, R. J., West Australian Pastoral and Colonization Co., Ltd., Kojunup, West Australia—*Free Life Member*
1890 Kerr, James, The Aboukir Company, Limited, Ramleh, Egypt—*Free Life Member*
1864 King, David, Dunedin, New Zealand
1875 Leithhead, James, Mokoia, Woodville, Hawkes Bay, New Zealand
1885 Lowrie, William, Prof. of Agriculture, Roseworthy, South Australia—*Free Life Member*
1885 Macdonald, A. C., Department of Agriculture, Grahamstown, Cape of Good Hope—*Free Life Member*
1891 M'Dougal, Jas., Bonnyrigg, St Andrews, New Zealand

Admitted
1871 M'Dougall, J. W., 48 Wellington Place, Toronto, Ontario, Canada
1883 Macpherson, John, Sorrento, San Diego Co., California, U.S.A.
1860 Mein, N. A., Hotel de Emperoure, Boulevard, Dunbanchago, Nice
1889 Middleton, T. H., Baroda College, Baroda, India—*Free Life Member*
1859 Mills, G., Glenmona Park, Bung Bong, Victoria
1861 Mitchell, David, Dalton, Otterlail County, Minnesota, U.S.
1883 Mollison, James, jun., Fort-Macleod, Alberta, N.W.T.
1886 Moos, N. A. F., Bombay, Poona—*Free Life Member*
1861 Morison, James, Topeka, Kansas
1886 Mukerji, N. G., Bhowanipur, Calcutta—*Free Life Member*
1878 Mundell, Walter, Tourisfield, Brandon, Manitoba
1888 Mutter, Major J. M., Somenos Ranch, Somenos, E. and N. Reg., Victoria, B.C., Canada
1878 Nonnen, J. E., Norway—*Free Life Member*
1875 Pringle, A. T., 42 Market Street, Sydney, N.S.W.
1877 Pudney, R. L., Dookie Farm School, Cashel, Victoria, Australia—*Free Life Member*
1878 Robertson, J., of Golden Grove, Adelaide, South Australia
1859 Robertson, W. M., 32 Bedford Street, Port Hope, Canada

Admitted
1880 Scott, Charles, South Africa, care of John Scott, Detective Department, Central Police Chambers, Glasgow
1892 Scheult, Louis C., Santa Rosa, Arima, Trinidad—*Free Life Member*
1866 Shiels, George, Monett, Mo., U.S A.
1887 Steele, Daniel, Agricultural Manager, Lake Copais Company, Ltd., Athens Agency, Athens, Greece—*Free Life Member*
1873 Turner, Peter, Balsam Grove, Drumquin, Ontario, Canada
1869 Tweeddale, George W., Ivy Hill, Warminster, Nelson County, Virginia, U.S.
1871 Tweedie, Richard, The Forest, Clydesdale Stud Farm, Douglas, Kansas
1895 Vuigner, Raymond, 46 Rue de Lille, Paris
1867 Walker, J., Grassmere, Stonewall, Winnipeg, Manitoba
1862 Walker, John, Vergelegen, Rosebank, Cape Town
1874 Walker, R. B., Queensland
1885 Wallace, Williamson, Egyptian College of Agriculture, Ghiezeh, Cairo, Egypt
1852 Watson, Wm., Beecher Wills, Illinois, U.S.
1894 Welsh, Alexander C., Aboukir Land Co., Limited, Defschon Farm, Kafr-el-Dawar, Egypt—*Free Life Member*
1865 Whyte, James, Waimea Road, Nelson, New Zealand
1879 Wilson, John, jun., Gilbrea, Oakville, County Halton, Ontario—*Free Life Member*
1858 Wotherspoon, Archibald, West Oxford, Canterbury, New Zealand

## MEMBERS WHOSE RESIDENCES ARE UNKNOWN.

[*Members knowing the present Address of the following Gentlemen, or being aware of their Death, will please communicate with the Secretary, 3 George IV. Bridge, Edinburgh.*]

1870 Aitchison, Peter (late West Garleton, Haddington), America
1869 Aitken, Robert, late Kilmany, Cupar-Fife
1883 Allan, Gavin, late 54 Old Dumbarton Road, Glasgow
1879 Anderson, John, late Castlehill, Blairgowrie
1870 Anderson, John S., late Dalhousie Mains, Dalkeith
1865 Baillie, John B., late of Leys, Inverness
1880 Balfour, J. H., late 7 Glencairn Crescent, Edinburgh
1883 Bardgett, John, late Edinburgh and Yorkshire College, Leeds—*Free Life Member*
1883 Bertram, Hugh, late Edinburgh
1873 Bisset, Hugh, late Pitarrow, Laurencekirk
1870 Blacklaw, Alex. Scott (late Milton of Arbuthnot, Fordoun), Brazil
1873 Bland, Thos., late Greystone, Tullynessle
1883 Boden, W. F., late Kinsteary Lodge, Nairn
1888 Bonallo, W. C., late Clandaboye, Co. Down
1880 Broad, Anthony, late Edinside Road, Kelso
1878 Brodie, William, late of Bush, Barkerland, Dumfries
1874 Bruce, A. H. T., late of Falkland, Ladybank

1875 Bruce, William L., late Glenkill, Lamlash
1870 Bryan, F. G. D., late 73 Bath Street, Glasgow
1877 Bryce, W. C., late 27 Berkeley Terrace, Glasgow
1864 Brydon, H., late Knocknarling, New Galloway
1882 Cameron, Donald, late Mossfield, Oban
1862 Cameron, William, late Factor, Kingussie
1871 Campbell, George, late Rhodes, North Berwick
1878 Campbell, William, late Carterton, Lockerbie
1880 Chaplin, G. Robertson, late of Murlingden, Brechin
1880 Chaplin, Captain T. R., late Lawhead House, Carnwath
1881 Chirnside, John, late 48 Albany Street, Edinburgh
1874 Chisholm, John, late East Kirkland, Wigtown
1876 Christie, James M., late Sunnyside, Prestonkirk
1872 Clark, John Moir, late Kinchyle, Fitzjohns Avenue, London
1869 Clark, Matthew, late Croftengea, Alexandria
1873 Coningham, W. J. C., late High Street, Haddington
1864 Cousland, Jas. (late Banker, Denny), Glasgow

Admitted
1875 Craig, H. V. Gibson, late Deans Court, Wimborne
1870 Craig, Robert, late Airdrie, Kirkbean, Dumfries
1867 Craig, Robert, late Tarbert, Lochfyne
1875 Craig, William, late Old Meldrum
1860 Dalziel, Alex., late Glenwharrie, Sanquhar
1875 Dangerfield, Edward (late Balboughty, Perth), U.S.A.
1887 Deans, John, late East Fenton, Drem
1884 Dick, John P., late Killelan House, Campbeltown
1883 Dowall, J. P., late Kelly Bleachfield, Arbroath
1867 Downie, William, late Kinbroom, Rothienorman
1864 Drummond, John, of Balquhandy, late Guilton Rectory, Wingham, Kent
1874 Duff, Thomas, late Manor House, Sidmouth, Devonshire
1868 Duncan, James (late Killichonan, Rannoch), New Zealand
1884 Elliot, Robert, late Burnmouth, Newcastleton
1870 Ferme, Chas., late Blackhall, Tulliallan
1870 Fisher, John, late Knells, Carlisle
1870 Forbes, C. W. L., late Aberfeldy
1872 France, C. S., late 11 Bridge Street, Aberdeen
1873 Fraser, H. N., late Tembain, Grey Town, King William Town, Cape Colony
1875 Gibson, Francis, late Oatfield, Drem
1871 Gibson, J., late 34 Abbotsford Place, Glasgow
1875 Gilchrist, Wm., late Knivocklaw, Loudoun
1884 Gillespie, Wm., late Gateside, Douglas
1873 Glen, James, late Helensburgh
1873 Glendinning, G. P., late Dalmeny Park
1875 Gordon, A. Hay, late of Mayen, Huntly
1866 Gordon, Christ., late Cannerie, Parton
1885 Gordon, James G., late Elmwood, Inverness
1870 Gordon, John (late Culraven, Kirkcudbright), America
1863 Gordon, Thomas Dempster, late of Balmaghie, Castle-Douglas
1870 Greig, James A., late Edinburgh
1869 Greig, P. M., late 56 Inverleith Row, Edinburgh
1878 Grieve, Gilbert, late Cardiff
1875 Haig, Wm. (late North St., St Andrews), Australia
1871 Hain, Thomas, late Glasgow
1861 Hamilton, Daniel, late 66 Hutchison Street, Glasgow
1871 Hardie, Charles, late Primrose, Dunfermline
1876 Harper, F. V., late Bridgend, Linlithgow
1872 Hazle, Alex., late of Blackcraig, New Cumnock
1878 Hope, William James, late East Barns, Dunbar
1871 Horn, John, late of Thomanean, Milnathort
1871 Hume, George, late 9 Inveresk Road, Musselburgh
1883 Hutchinson, Alan, late Camserney Cottage, Aberfeldy
1865 Inglis, Peter, late East Pilton, Ferry Road, Edinburgh
1863 Jack, Michael, late Peggy's Mill, Cramond
1870 Jackson, John, late Bush, Ewes, Langholm
1878 Jardine, A. M., late Kilnwick Hall, Cranswick, Hull
1883 Laidlay, R. W., late Halls, Dunbar
1881 Lang, Hugh, late 11 Kew Terrace, Hillhead, Glasgow

Admitted
1868 Lawson, George Stoddart, late Edinburgh
1867 Lawson, Thomas, late Sandyford, Kirriemuir
1884 Lindsay, James (late Wester Happrew, Stobo), Australia
1863 Livingstone, T. L. F., late of West Quarter, Falkirk
1865 Lorimer, J., late Achrossan, Tigh-na-bruaich
1883 Lumsden, T. W. M., late Balharg, Meigle
1890 Lyall, Robert J., late Powis, Montrose
1870 McAdam, J. N., late High Trees, Marlborough
1884 M'Cowan, George, late Glenmanno, Penpont, Thornhill
1872 Macfarlane, John, late 19 Ann Street, Hillhead, Glasgow
1868 Mackenzie, Sir Jas. D., of Scatwell, Bart., late Dingwall
1874 Macleod, D. D. M'L., late Nairn
1871 M'Lellan, David, late of Marks, Kirkcudbright
1860 Macpherson, John (late Killihuntly, Kingussie), Ontario, Canada
1876 M'William, Mrs, late Aberdeen
1864 Marr, J. A., late of Alderston, Mid-Calder
1886 Maxwell, Wellwood, late of The Forest, New Galloway
1885 Menzies, John G., late 6 Grosvenor Crescent, Edinburgh
1873 Michael, James, late Dunmore, Stirling
1873 Miller, C. W., late Wellwood, Bridge of Allan
1874 Mitchell, Wm., late North Ossemsley, Lymington
1873 Mollison, James, late Pavenham, Bedford
1882 Muir, John G., late Anderston Foundry, Glasgow
1862 Muirhead, E. W., late The Hill, Putney, Surrey
1863 Murhead, George (late Durdie, Errol), London
1860 Norman, Wm., late Hall Bank, Aspatria —*Free Life Member*, 1873
1870 Patterson, Alex., late Lawhill, Auchterarder
1884 Pitcairn, D. D., late Blackhouse, Reston
1878 Pitcairn, Henry H., late Tiroran, Mull
1882 Pollock, John, late Pollockshaws
1881 Powrie, Archd., late Lairwell, Perth
1863 Primrose, James Thomson, late Sauchland, Ford
1870 Ralston, A. R., late Straiton, Maybole
1867 Ralston, Andrew W. (late Lagg, Ayr), America
1870 Rawline, J. D., late Rose Farm, Formby, Liverpool
1861 Richmond, G., late Balhaldie, Braco
1865 Ritchie, Charles, late Ladoga Lodge, Musselburgh
1870 Robertson, James A. (late Chapel Park, Kingussie), Virginia, U.S.
1870 Robertson, Peter D., late 9 King Street, London
1862 Russell, John, late Saughtonhall Mains, Edinburgh
1889 Russell, Thomas, late Greenhill, Avonbridge
1870 Saunders, R. B., late Hutton Grange, Gisburgh
1875 Scobie, N. F., late of Hawkhill, Inverness
1864 Scott, Lord Charles, late Eildon Hall, St Boswells
1864 Shand, William (late Crichton, Ford), New York

Admitted
1873 Sievewright, William (late Solicitor, Lerwick), New Zealand
1879 Simpson, Alexander, late Inverness
1869 Simpson, George, late 2 Lauder Road, Edinburgh
1887 Simpson, James, late Ingleston, Ratho
1871 Simson, Thomas, late Skelpie, Cupar
1863 Slipper, Robert B., late 427 New Cross Road, London
1873 Smith, William B., late 32 Ashchurch Grove, London—*Free Life Member*
1862 Steedman, John, late Charlestown, Dunfermline
1870 Stewart, D., late Unthank, Langholm
1864 Stirling, Captain Gilbert, late Royal Horse Guards
1887 Stirling, James, late Tamano, Braco
1865 Sutherland, E. C., late of Skibo, Dornoch
1885 Syme, David F., C.A., late 31 St Andrew Square, Edinburgh
1872 Thomas, William, late Pinnacle, Ancrum, Jedburgh

Admitted
1873 Thomson, A., late Morton Mains, Lothianburn
1875 Thomson, Thomas, late Bankhead, Alloa
1884 Todd, John, late Tinwald Shaws, Dumfries
1878 Turnbull, D., late Brieryards, Hawick
1877 Underwood, Peter, late Mains of Essich, Inverness
1888 Vincent, E. H., late Lauder Barns, Lauder
1861 Wallace, John, late Illieston, Broxburn
1871 Wallace, Wm., late Newton of Collessie
1872 Watson, Patrick, late Friarstown House, Tullaught, Dublin
1884 Watson, W. H., late Ruthven, Coldstream
1881 Weber, F. H., late 41 High Street, Guildford—*Free Life Member*
1878 Williamson, James, late Greenhead, Wishaw
1872 Wilson, George, late Greenhill, Selkirk
1883 Winton, Alex., late Viewhill, Ardersier
1878 Wyatt, S., late Nydie Mains, St Andrews

TOTAL NUMBER OF MEMBERS, 5310.

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## HONORARY MEMBERS.

# DIPLOMA HOLDERS, FREE LIFE MEMBERS.

By a By-law passed in 1873, with reference to the Supplementary Charter of 1856, successful Candidates for the Society's Agricultural Diploma are thereby eligible to be elected Free Life Members of the Society.

In 1882, the holders of the Diploma memorialised the Council, pointing out the want of some distinctive title attached to the Diploma, and praying that the title F.H.A.S. (Fellow of the Highland and Agricultural Society of Scotland) be granted to them. The Council acceded to the prayer of the Memorial.

Admitted
1879 Aitken, John M., Norwood, Lockerbie
1882 Alexander, A. S., 216 Clerk St., Chicago
1876 Anderson, R. Lang, Manager, The Aboukir Co., Limited, Ramleh, Egypt
1873 Ashdown, A. H., M.R.A.C., Castle House, Shrewsbury

1887 Banerjee, N. N., Calcutta
1883 Bardgett, John, late Yorkshire College, Leeds
1883 Basu, Giris Chandra, 196 Bowbazar St., Calcutta
1884 Benson, R. A., Duchy of Cornwall Office, Liskeard, Cornwall
1885 Birch, Walter de Hoghton, Kerry, Montgomeryshire
1892 Borland, John Kennedy, North Balloch, Ayrshire
1878 Bramwell, John, River Plate Trust Loan and Agency Co., Calle San Martin 56, Buenos Ayres
1891 Brown, John, Hillhead Farm, Airdrie
1873 Brown, William, Earlsmill, Forres
1873 Browne, Colvile, M.R.A.C., 26 Mill St., Bedford
1873 Brydon, Robert, The Dene, Seaham Harbour
1874 Burn, Forbes, care of The National Agricultural Society of Victoria, Bourke Street, Melbourne
1882 Buttar, Thos. A., Corston, Coupar-Angus

1873 Campbell, George, Kilkea, Mageny, Co. Kildare
1892 Campbell, John, care of —— Johnstone, Hamilton Place, Castle-Douglas
1885 Campbell, Robt. J., Cuil, Castle-Douglas
1879 Cannon, James, Urioch, Castle-Douglas
1878 Carr, Robert, Felkington, Norham, Berwick-on-Tweed
1887 Carrington, George, M.R.A.C., Missenden Abbey, Great Missenden, Bucks
1884 Clinton, W. E., Pelham, Moorcourt, Stroud
1891 Coward, T. A., Eden Town, Carlisle
1890 Crabtree, Henry, 54 Wakehurst Road, Clapham Junction, London, S.W.
1879 Craig, John, Innergeldie, Comrie
1880 Craig, Wm., Gwydyr House, Crieff

1894 Daine, Herbert S., Harris Institute, Preston
1887 Davies, Edward Smith, Atchley, near Shifnal, Shropshire
1894 De la Mothe, Joseph, Agricultural College, Aspatria
1886 Dickson, Thos. A., Estate Office, Overstone Park, Northampton
1888 Drieberg, Christopher, Colombo, Ceylon
1892 Duncan, James L., Birgidale, Knock, Rothesay
1878 Dunlop, Andrew T. L., Morriston, Maybole

1873 Eley, Rev. Dr Wm. Henry, Etchingham Rectory, Hawkhurst, Kent

Admitted
1873 Elliot, Prof. Thomas John, M.R.A.C., Hole Park, Rolvenden, Kent
1882 Ensor, Thomas Henry, 54 South Street, Dorchester
1874 Erskine, Henry, Buccleuch Square, Langholm

1886 Faber, Alfred D., Belmont, Ilfracombe, Kent
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